Clarifying ethical stances in conservation: a trolley problem thought experiment

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Abstract

Conservation policies often need to integrate scientific predictions with ethical considerations. However, different normative ethical systems at the root of conservation approaches often support different decisions, and the moral stances of stakeholders are influenced by diverse societal values and perceptions. This creates the potential for dilemmas and conflicts. Here we adapt the well-known trolley problem thought experiment to a conservation context; exploring variations in how the problem is framed enables us to highlight key concepts that need to be considered in decision-making (asymmetry in numbers, victims, and impacts; temporal and spatial asymmetry; uncertainty; causal relationships and stakeholder involvement). We argue that the trolley problem offers a simplified, yet flexible, framework to understand and predict the factors underlying differences in moral stances across diverse conservation issues, foster communication, and facilitate informed decision-making in conservation practice.

Keywords: Conservation, Ethics, Management, Metaphor, Thought experiment, Trolley problem

1. Different worldviews can motivate diverging conservation decisions

Conservation practitioners often have to make decisions about actions which are believed to benefit one entity of nature (*sensu* Johnson, 1983 and Lehnen et al. 2022; e.g., a group of individuals, populations, species, or ecosystems; see Table 1 for definitions), but may be detrimental for another. These decisions are rarely straightforward. Consequences are often uncertain, and trade-offs can be perceived differently by stakeholders, due to ecological, economic, political, philosophical or psychological factors (Bennett, 2016). Conservation decisions must therefore account for the diversity of nature's values and relationships between people and the environment (Ives and Kendal, 2014), and consider arguments beyond the scientific domain, to assess the morality of an action and guide decisions (IPBES, 2022). Note that we use the term 'value' in the sense of 'assigned value' (i.e. a value attributed to something) as opposed 'held value' (i.e. life goals and principles; cf. Table 1).

Western conservation literature outlines three primary normative, ethical theories: 1) consequentialist; 2) deontological; and 3) virtue. Under a consequentialist ethical framework, values are typically attributed to different entities of nature according to a given ethical perspective: ecocentrism attributes intrinsic value to species and ecosystems, biocentrism attributes intrinsic value to living organisms, sentientism attributes intrinsic value to individuals that can experience consciousness beyond pain and pleasure, and anthropocentrism attributes intrinsic value to humans and instrumental value to other species (i.e. they are valuable insofar as they benefit humans) (Latombe et al., 2022). Conservation targets could accordingly be to maximise native biodiversity (i.e. "coevolved, natural communities"; traditional conservation, Soulé 1985), maximise the benefits humans get from nature (new conservation, Kareiva and Marvier 2012 - but see Appendix S1 for a more nuanced description), or minimise animal suffering (conservation welfare, Beausoleil et al. 2018). By contrast, under a deontological ethical framework, actions are considered under the perspective of duties and rights. Deontologists would reject the killing of animals to decrease overall suffering (a consequentialist perspective) if they consider that animals have inalienable rights to life (Bichel and Hart, 2023; Korsgaard, 2018). Thirdly, virtue ethics advocates for actions that are driven by desirable human qualities, i.e. virtues (Hursthouse and Pettigrove, 2018), such as compassion for sentient animals (compassionate conservation, Wallach et al., 2018).

In practice, conservation decisions need to consider both normative, ethical perspectives, and people's perceptions of the morality of actions, with the latter influenced by additional subjective, cognitive and emotional factors. For example, preference for immediate rewards over long-term or distant costs is a highly context-dependent psychological trait (Critchfield and Kollins, 2001; van der Wal et al., 2013), which have implications for conservation: people are adverse to immediate sacrifices of concrete, immediate benefits that contribute to long-term climate change (Swim et al., 2009). Similarly cultural preferences, species charisma, nativism, and relationships with entities of nature can influence decision making (Díaz et al., 2018; Lehnen et al., 2022).

Differences in normative ethical perspectives and in cognitive or emotional preferences can generate different stances on conservation actions, especially for complex ecological systems involving many entities of nature, potentially escalating towards conflicts (Crowley et al., 2017; Estévez et al., 2015; Redpath et al., 2013). These differences have led to multiple and yet unresolved disputes in the scientific literature (Appendix S1). The interplay between ethical views and subjective or intersubjective preferences can also generate personal dilemmas (internal conflicts), for example when conservation impacts species differently, or when normative perspectives conflict with a cognitive or emotional preferences (rationality vs. emotion). Such external and internal conflicts can lead to a lack of decision making and inertia (Peterson et al., 2005). This suggests a system is needed for conservation practitioners to systematically compare positions and how they vary with context, promote communication, and identify points of divergence or agreement.

2. The trolley problem thought experiment as a tool to capture the diversity of conservation stances

Metaphors are often used to conceptualise issues and clarify moral reasoning (Johnson, 2014). They can be used to create thought experiments and simplify real, complex situations and explore how moral intuitions naturally emerge, or to elaborate more robust moral stances under normative theories (Haidt, 2001; Lakoff and Johnson, 1999; Singer, 2005). Thought experiments have for example been proposed to clarify the ethical system of compassionate conservationists (Rohwer and Marris, 2019). The trolley problem (Foot, 1967; Thomson, 1976) is a well-known thought experiment to explore ethical dilemmas when both an action and an absence of action will necessarily affect humans negatively, and has been used both in arguments for different normative ethics (e.g. Singer, 2005) and in moral psychology experiments (e.g. Greene et al., 2001; Navarrete et al., 2012). In its general formulation, a carriage of a tram (hereafter, a trolley) is out of control and cannot be steered or slowed down. It is heading towards five people who are stuck to the track and will kill them upon impact. The choice is to pull a lever that will divert the trolley onto another track, where another person is stuck. The (forced) choice is to act and save five but kill one other, or do nothing and let five people die. Should the lever be pulled?

The trolley problem can be adapted for conservation by replacing the humans on the tracks with entities of nature. The trolley thus becomes a metaphor for an environmental change that will cause harm (Figure 1a). For simplicity, we consider individual animals, but the reasoning can be extended to different taxa, genes, populations, species, or ecosystems (i.e. different entities of nature). We also mostly consider situations with two options though of course in practice multiple options may be available, sometimes in combination, with different outcomes. The trolley problem metaphor is crude (cf. Bauman et al. 2014), but we argue that this simplicity allows for trade-offs in conservation to be systematically explored and that it can thereby help decision-making under moral quandaries.

Consider a scenario where a lake is drying out (Figure 1b). If the lake is lost, a large number of beavers will die (they cannot move to an alternative habitat). A hydrologist proposes diverting a nearby river to feed the lake. However, if the river is diverted, another beaver population will lose its habitat and die. Importantly, in this version of the trolley problem, the environmental change is of the same nature as both populations would die due to the lack of water, represented by the trolley as a metaphor in the thought experiment, and the two populations are distinct. Should the inter-basin water transfer scheme be built?

In the following, we develop variations of the trolley problem to explore key concepts in different conservation contexts (Tables 1 and 2). We do not seek to discuss the validity of different conservation approaches or moral stances under conservation trolley problem variations. Rather, we seek to break down conservation issues into core elements, and explore how they will potentially influence moral intuitions or reasoning in conservation contexts, to identify where conflicts or moral dilemmas may arise. The conservation trolley problem can thus be seen as a visual aid to generate a catalogue of concepts that can affect moral judgment and play a role in conservation decisions. In particular, we develop variations covering three main concepts that are likely to influence conservation decisions (with different levels of relevance for comparing normative ethical theories or for discussing subjective individual stances on conservation issues): i) asymmetry between the tracks (of numbers, of victims, of impacts and spatio-temporal), ii) uncertainty and risk about the outcome of an action and unforeseen consequences, and iii) causal effects and the involvement and responsibility of stakeholders.

3. Variations of the conservation trolley problem involving asymmetry between conservation options

3.1. Asymmetry of numbers

Under the main normative theories, the number of victims should not influence a decision (one should always save the larger number of people under utilitarianism, and numbers should not matter for deontological considerations). However, in a moral psychology context, it has been shown that the ratio of the number of people on each track can influence people's decision (Nakamura, 2012). Different conservation issues will put different population sizes against each other (Table 2a). For example, in trophy hunting (Section 5.2.1) one or few individuals may be killed by a wealthy hunter to generate revenues that will contribute to saving many other individuals. By contrast, lethal control of a population of an invasive alien species is likely to result in the death of many individuals.

The ratio between the size of the impacted and global populations may also be important. Under biocentric and sentientist perspectives, which give intrinsic value to individuals, the absolute size of the impacted population will likely determine if there is a dilemma. Under the ecocentric perspective, which gives intrinsic value to species and populations, the relative size of the impacted population with respect to the total local or global population of the species, representing the threat on the population or species, will likely determine if there is a dilemma. For example, the eradication of a large invasive population of the house mouse from an island might be argued to be justified if it saves a small population of a globally rare species of albatross. In this case there is variation in both the numbers of animals affected on the island, and the relative global abundances of the species.

3.2. Asymmetry of victims

As in the mouse-infested island case, conservation actions usually affect different species, making conflicts and dilemmas likely to emerge when species are attributed different intrinsic or instrumental values, or are considered to have different rights, but differ in population size (Table 2b). For example, trophy hunting (Section 5.2.1) targets charismatic species that are often attributed high values. Species relocations (Section 5.2.4) will also target species of high value, with potential deleterious effects on other species. From a consequentialist perspective, impacting a single, highly valuable individual could be considered equivalent to impacting many, less valuable individuals, if we consider these values can be mathematically summed-up (Jarić et al., 2024; Latombe et al., 2022). This equivalence will depend on the different elements (be they ecological, ethical, subjective) that determine the value attributed to an entity of nature, e.g. their sentience, rarity, charisma, cultural or economic importance, or endemicity (IPBES, 2022). Asymmetry of victims can be represented in the trolley problem by considering different species on the tracks.

3.3. Asymmetry of impacts

Conservation actions might aim at individual deaths or population extirpation, but might also cause or prevent the deterioration of the physical state and wellbeing of individuals. Pollution and changes in land-cover, food availability, hydrology or temperature affect the behaviour (e.g., sleep patterns, activity level, risk-taking) and the physiology (e.g., metabolic rate) of animals (Killen et al., 2013; Raap et al., 2015). In the trolley metaphor, non-lethal impacts can be represented by letting the trolley injure, but not kill, the individuals (Table 2c). The dilemma arises if many individuals are suffering non-lethal impacts in one case, and few individuals would die or suffer a higher impact in the other. Non-lethal impacts, such as food deprivation, have led to public reactions and changes in conservation actions (ICMO2, 2010). Normative ethical theories should be clear regarding how they weight non-lethal and lethal impacts (see e.g. Driscoll and Watson, 2019), although the cause of the impacts is also likely to matter (see Section 5 below).

3.4. Temporal and spatial asymmetry

Temporal and spatial discounting is a well-known cognitive trait that means people value the consequences (reward or cost) of an action less if the consequences occur far away or a long time in the future (Critchfield and Kollins, 2001; Green et al., 1997; Perrings and Hannon, 2001). Similarly, people tend to underestimate future harm, i.e. optimism bias (Perrings and Hannon, 2001). These effects have well known consequences for how people value conservation actions, e.g., in response to climate change (Baum and Easterling, 2010; Essl et al., 2018) and biodiversity loss (Essl et al., 2017; Kuussaari et al., 2009). The consequences of environmental risks can, however, be so important from a moral perspective that decisions arguably should not include temporal and spatial discounting (Böhm and Pfister 2005). Temporal and spatial asymmetry is also important from normative perspectives. For example, should individuals that are not born yet, or that are prevented to be born due to the implementation or absence of a conservation action influence conservation decisions? Temporal and spatial asymmetry can be represented using the trolley problem metaphor when entities are far away from the junction on the tracks (Table 2d).

4. Uncertainty, risk and unforeseen consequences

In the original trolley problem, and in the different variations above, the consequences of actions are precisely known. However, this is rarely the case in conservation. In reality, uncertainty and risk will interact with asymmetry to generate additional dilemmas and conflicts. This is especially true if the benefits of an action (pulling the lever) have been overestimated, or when the costs in the 'business as usual' scenario (not pulling the lever) have been underestimated. Uncertainty and risk can be added to the trolley problem by adding probabilistic branching on the tracks (Table 2e.i), and by representing the lack of information about those probabilities, or even about the abundance and number of species on a track (Table 2e.ii).

Uncertainty is inherent to conservation and hard to reduce or even to quantify (Canessa et al., 2016). Rationally, there are multiple ways of approaching risky dilemmas, e.g. take the action which ensures the least negative outcome, the best average outcome, or has the potential for the most positive outcome. These approaches can be compared in normative perspectives. However, from a moral psychology perspective, agents tend to use different decision-making strategies if outcomes are uncertain, resorting less on consequentialist or utilitarian approaches (Kortenk Amp and Moore, 2014). If decision-makers are risk adverse, as is often the case, then business as usual is often favoured even when being the least favourable option from a consequentialist perspective (Canessa et al., 2020). However, as in the metaphor of Chesterton's fence, there can be value in being inherently cautious of change (i.e., don't remove a fence if you don't know why someone put it up in the first place).

5. Variations of the conservation trolley problem involving causal effects and the involvement and responsibility of stakeholders

Asymmetry and uncertainty variations capture important considerations met by conservation managers facing environmental issues, and are important both for defining and comparing normative theories, and for understanding moral psychology in conservation. However, causal relationships between the presence of an entity, the death of another, and the type of action taken are seldom explicitly considered in conservation decisions. Variations of the original trolley problem have been widely used to examine these issues, e.g., how stakeholder involvement and causality are important for ethical decisions involving humans. These variations have been used to explore normative theories, for example for the principle of double effect (see below) and to understand ethical decision-making in moral psychology.

5.1. Giant variations of the original trolley problem

Although initially outlined by Foot (1967), the trolley problem only gained prominence through Thomson's (1976) famous "fat man variation" (hereafter termed more neutrally "giant on a footbridge variation"; Figure 2a). In this variation, there is only one set of tracks, to which five people are stuck. A person on a footbridge next to a giant realises that pushing the giant onto the tracks will stop the trolley and save the five people, killing the giant. Should they push them?

These variations have been discussed from a normative theory perspective (e.g. FitzPatrick, 2009; Thomson, 2008). In particular, the principle of double effect has been used to defend the action of pulling the lever but not pushing the giant. According to this principle, it is not morally acceptable to intentionally cause a negative effect while achieving a positive one, in particular as a means to an end, i.e. to push and kill the giant as a means to save five people. Conversely, causing unintended harm while attempting a good deed, as in the original trolley problem where the bystander diverts the trolley to save five but inadvertently kills one, is viewed more favourably (McIntyre, 2019). These variations were taken further by the "giant on a loop" variation (Singer, 2005; Thomson, 1985). A lever can be pulled that would divert the trolley to a loop on which the giant is attached, therefore stopping the trolley but killing the giant (Figure 2b). This last variation was used to show how small differences between variations can affect whether actions are viewed as moral or not.

These variations have also been used to explore people's moral psychology. In the original trolley problem, most people (around 90% across multiple studies) act consistently with a utilitarian approach (Table 1) and sacrifice the single person (Navarrete et al., 2012), whereas most people would refuse to push the giant (Greene et al., 2001; Singer, 2005). As has been observed using functional magnetic resonance imagery, there is a stronger emotional response to the idea of killing a person by pushing them than the idea of killing someone by pulling a lever (Greene et al., 2001).

Discussions around these thought experiments have significant implications for understanding ethical decision-making, emphasizing how causal relationships between life and death and the directiveness of actions influence moral choices, both for normative theories and for moral psychology. These considerations are analogous to decision on conservation practice, e.g., trophy hunting, lethal management of invasive alien species, or sanitary culling. Such practices often generate conflicts among stakeholders but also conservationists (Baynham-Herd et al., 2018; Driscoll and Watson, 2019; Wallach et al., 2018). The degree of stakeholder involvement and the impact of the species being managed on other entities of nature will vary from case to case, and such differences may be crucial to understand different stances about conservation actions. Here we explore several such conservation decisions using variation of the trolley problem.

5.2. Variations around direct involvement and causality for conservation issues

5.2.1. Trophy hunting

In this conservation analogue of the "giant on a footbridge", the option is to push an animal on the tracks (i.e., kill it) to save several animals of the same or a different species further down the tracks (Table 3a). This can be seen as a metaphor for a (virtuous) version of trophy hunting—hunting charismatic animals is allowed to fund conservation of entire populations. Another variation more in line with trophy hunting would be not to direct kill an animal, but to allow someone else to do it, which may decrease the impression of responsibility (e.g. plausible deniability) and potentially change the outcome. Further subtleties can be included, such as the motivation of the person who would kill the animal (Macdonald et al., 2016), the charismatic attributes of the animal, the degree to which funds raised through trophy hunting go directly into conservation or to those who facilitate the hunting, and the degree to which any of the actions causes suffering, although these considerations may be harder to explicitly depict in the thought experiment.

5.2.2. Invasive alien species

Invasive alien species (IAS) are among the main threats to global biodiversity (Bellard et al., 2016; Maxwell et al., 2016; Roy et al., 2024). The eradication of IAS (that typically involves the lethal control of invasive alien animals) has been found to be among the most effective conservation interventions (Jones et al., 2016; Langhammer et al., 2024; Sankaran et al., 2024). However, lethal control of IAS has been criticised for being unethical when applied to sentient beings, particularly vertebrates (Wallach et al., 2020, 2018), leading to conflicts between stakeholders (Crowley et al., 2017). The causes for such conflicts are often not obvious, and may be due to concepts of asymmetry and uncertainty, but also to involving actions with the direct intention of killing animals, such as trapping, hunting or poisoning (Crowley et al., 2017). The main differences to the trophy hunting variation are the different number of individuals affected and the threat posed by IAS individuals to individuals of native species (or native entities of nature), warranting a distinct variation to examine differences in normative views and in people's stances between IAS lethal control and trophy hunting.

For a better understanding of this causal relationship, we suggest two variations of the conservation trolley problem (Table 3b). In both variations, an individual of the IAS sets the trolley in motion, for example after its presence is recorded from a weighing scale. In the first variation, the option is to pull the lever, and send the trolley on a path that will kill the

IAS individual inside it. This represents environmental management that benefits the native species but is detrimental to the IAS. In the second variation, the option is to push a button that will directly kill the IAS entity and stop the trolley. It is also possible to distinguish multiple reasons for the IAS being on the trolley, to reflect different pathways of introduction, intentional or unintentional (e.g. as game or stowaway, respectively) (Hulme et al., 2008) (see Appendix S3 for a discussion on stakeholder involvement). Additional considerations may be important to consider and depicted in the trolley problem, for example if the invasive taxon is endangered in its native range (e.g., the Sea Lamprey *Petromyzon marinus*, Guo et al., 2017, and other examples, Tedeschi et al. 2024).

5.2.3. Species culling

Species culling is used in conservation for various reasons (e.g., to prevent overconsumption and starvation through overpopulation, to decrease predation pressure, or to stop the spread of epizootics; Hervieux et al., 2014; Martel et al., 2020; VerCauteren et al., 2011; Wilson et al., 2015). Culling raises inherent ethical concerns (Wallach et al., 2018), and has generated opposition from the public (e.g., ICMO2 2010; Nugent et al. 2011). To conceptualise the issue, we propose two variations of the conservation trolley problem (Table 3c). As in the asymmetry of impact variation, we assume that the trolley will not kill an individual upon impact, but will injure it greatly, inflicting high levels of suffering. In the first variation, the option is to inject the animal with a lethal, quick, and non-painful poison. This variation explores the morality of killing a – potentially sentient – living being to prevent its future suffering. In the second variation, injecting the animal would save other animals from suffering (in the trolley metaphor the lever is somehow attached to the animal's vitals, injecting the animal kills the animal but puts the trolley onto an empty track). The second variation is similar to a situation when the presence of an IAS would not result in the death of native individuals, but would degrade the conditions of life of both native and invasive species. The difference for species culling is that entities are indistinguishable from each other, whereas for IAS, it is the introduction of specific entities that generates suffering.

5.2.4. Assisted colonisation

Assisted colonisation, the translocation of endangered species outside their indigenous range to prevent their extinction, can be contentious (Hoegh-Guldberg et al., 2008; Ricciardi and Simberloff, 2009). The consequences of translocation can be explored using a variation of the conservation trolley problem (Table 3d). The animal at threat from being killed is moved out of harm's way but onto another trolley. This second trolley is set in motion by the weight of the animal, and starts moving towards individuals of another species that will be killed or injured by the second trolley. Should the animal be moved?

6. Discussion and conclusion

Here we presented variations of the trolley problem for conservation to clarify and compare complex situations, i.e., as illustrative thought experiments (*sensu* Brun, 2017). These variations can also be used in a heuristic fashion (*sensu* Brun, 2017) to identify contexts likely to create ethical dilemmas, conflicts between stakeholders, or conflicts between normative theories (see Appendix S2), across conservation issues. Using the trolley problem to compare trophy hunting with the lethal control of invasive alien species, we can see that they: i) share a direct involvement of stakeholders, as there is a lethal action in both cases, but they differ in the relationship between the individual(s) being killed and the other individuals; ii) likely differ in the number of individuals that are killed; and iii) likely differ in the relative value of the entities of nature affected—trophy hunting often targets charismatic animals with high, local cultural value, whereas invasive species range from those that are highly desired to those that are highly despised (Jarić et al., 2020). The trolley problem allows a common depiction to explore which of these variations are likely to lead to disagreements and dilemmas.

Conservation actions can affect humans positively (e.g., by generating income) and negatively (e.g., by restricting activities). As the value attributed to humans likely differs from that attributed to non-human entities of nature, it will be important to additionally consider affected stakeholders in future thought experiments. The loss of different entities of nature important to humans can generate choices and dilemmas that are very difficult to resolve (Daw et al. 2015; see Appendix S3 for more details). It is similarly important to explore different levels of stakeholder involvement and causal relationships between entities of nature's existence and death, and combining these with asymmetry and uncertainty variations (see Appendix S2 for an example for invasive alien species). Doing so may prove especially useful to break down problems typified by multiple elements interacting in a complex system that do not have a single tractable solution, i.e., wicked problems (Game et al., 2014; Woodford et al., 2016).

The trolley problem metaphor is, of course, not appropriate for all conservation issues. The metaphor focuses on a crisis situation (an urgent choice needs to be made). By contrast, conservation decision-makers are often faced with choices made concerning pro-active actions (e.g., prevention) or long-term planning. The trolley problem does clearly demonstrate, however, that postponing conservation decisions or actions can have important and irreversible consequences (e.g. Naujokaitis-Lewis et al., 2018). In addition, the importance of the biodiversity crisis may warrant conveying a sentiment of urgency, just as if the trolley were moving towards the junction. Entities of nature also encompass multiple concepts, from individuals to collectives: it is less intuitive to apply the trolley problem to species than to individuals, and it is even less intuitive to compare impacts on individuals against impacts on species, communities or ecosystems, although the latter are central to conservation (Luque-Lora, 2023). The conservation trolley problem also lacks important conservation aspects such as the concepts of naturalness of conservation actions (is an action implemented by humans disconnected from nature?), and the different roles humans can take with respect to nature (observer, participant, partner, explorer, steward or manager) (Wienhues et al., 2023), although these concepts can be, at least partly, related to the involvement of stakeholders in the trolley problem. Finally, the trolley problem presents a forced choice among mutually exclusive actions, whereas real-world conservation often relies on combinations of sometimes related management actions.

Nonetheless, the trolley problem is a versatile tool to capture future impacts of different conservation actions (or lack thereof), and generate a wide variety of scenarios combining different variations. Trolley problem variations provide a robust foundation to develop nuanced and context-specific metaphors, explore and communicate management situations that can generate conflicts, and ultimately contribute to better informed and ethically sound conservation practices. To achieve this, we suggest it is important to: i) clarify the position of different conservation approaches based on normative theories, especially new and compassionate conservation; ii) develop variations and thought experiments that explicitly incorporate additional concepts such as naturalness; and iii) explore application of trolley problems and other thought experiments to moral psychology, for example through surveys, to better understand people's attitudes towards nature conservation.

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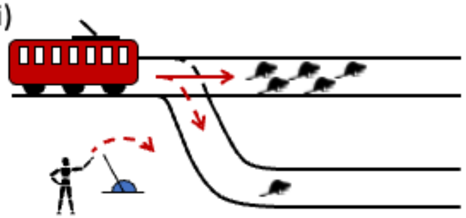
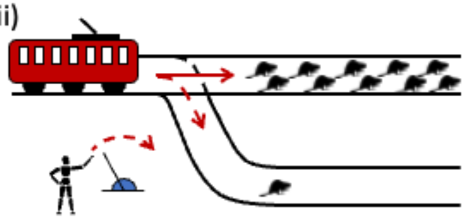
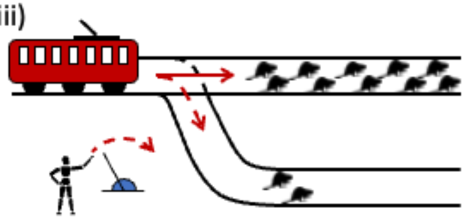
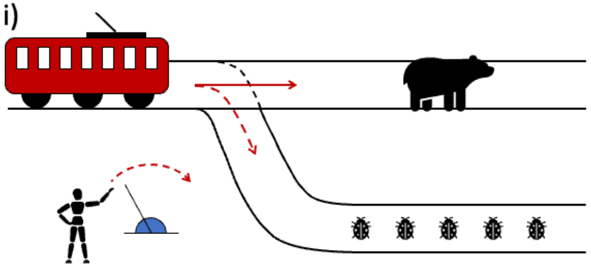
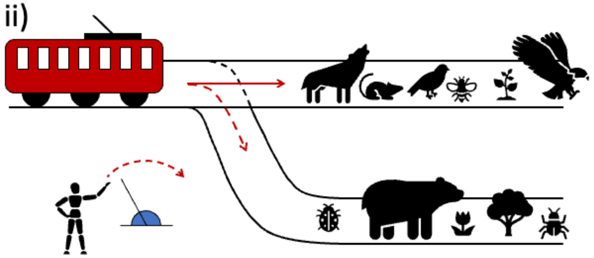
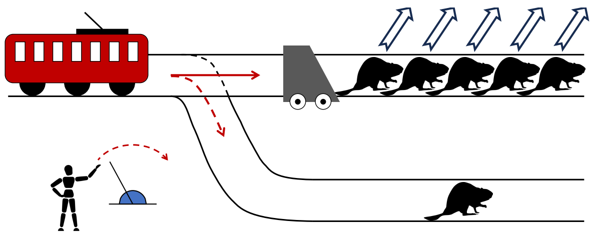
Table 1. Definitions of concepts related to the valuation of nature and its entities

Concept	Definition
Anthropocentrism	Ethical perspective that considers humans to be the sole, or primary, holder of intrinsic value, and therefore the concern of direct moral obligations. Non-human species are considered only in virtue of some relation they bear to humans (Norton, 1984; Palmer et al., 2014; Rolston III, 2003).
Assigned value	A value attributed to something (here mostly entities of nature) by someone, hereby expressing the importance they give to it compared to other things (Seymour et al., 2010).
Biocentrism	Ethical perspective considering all living beings as having intrinsic value and therefore the concern of direct moral obligations (Palmer et al., 2014; Rolston III, 2003).
Community of moral agents	The group of beings considered to have moral responsibility in their actions (Talbert, 2019).
Community of moral patients	The group of beings considered to have intrinsic value, and towards which moral agents have moral obligations (Warren, 2000).
Consequentialism	Normative ethical theory according to which an action morality is evaluated based on its consequences (but see Sinnott-Armstrong, 2023 for different types of consequentialism).
Deontology	A normative ethical theory considering that “choices are morally required, forbidden, or permitted” (Alexander and Moore, 2016).
Ecocentrism	Ethical perspective considering that species, their assemblages and their functions, as well as more broadly ecosystems, rather than individuals, have intrinsic value and are the concern of direct moral obligations (Palmer et al., 2014; Rolston III, 2003).
Entity of nature	“Any concrete or abstract part of nature, encompassing, for example species, landscapes, plants, animals, nature spirits and nature as a whole” (Lehnen et al., 2022). Here we focus on entities “which have morally significant interests” (Johnson, 1983).
Held values	Concepts or principles that human individuals deem important to them, underlying personal behavior, environmental beliefs, attitudes and decisions (Seymour et al., 2010). Adhering to a specific ethical perspective is a held value.
Intrinsic value	Value expressed independently of any reference to people as valuers. Assigning an intrinsic value to entities of nature, including habitats or species, means acknowledging they are worth protecting as ends in and of themselves (IPBES, 2022).
Instrumental value	Value given to an entity (individual or collective) based on its utility and how it benefits another entity capable of attributing a value (here humans). For example, dogs may have an instrumental value for herding sheep or as guard-dogs (IPBES, 2022).
Principle of double effect	Principle according to which it is permissible to cause a harm as a consequence of an action that achieves positive consequences if this harm is not intended, but it is not permissible to cause a harm

	intentionally, in particular as a means to achieve these positive consequences (McIntyre, 2019).
Sentientism	System considering sentient beings as the concern of direct moral obligations (Palmer et al., 2014; Rolston III, 2003).
Virtue ethics	Ethical perspective that emphasises the virtues, or moral character as the reason for action (Hursthouse and Pettigrove, 2018).

Table 2. Variations of the trolley problem with conservation analogues and insights for decision-makers. The focus is on issues of asymmetry and uncertainty. Each depicted animal stands for an entity of nature and could be substituted for other entities (e.g., genes, populations, or communities).

Trolley problem variations for conservation	Description	Issue(s) raised
Asymmetry variations		
a) Asymmetry of numbers (different numbers and ratio of entities of nature are affected)		
i)  ii)  iii) 	Conservation actions can affect different numbers of entities of nature. The absolute or relative number on each track can affect the acceptability of the decision to people.	• Doe the number of individuals saved justify the number sacrificed? Note: the options depicted are: i) kill 1 to save 5; ii) kill 1 to save 10; iii) kill 2 to save 10. • Does the relative size of the impacted population compared to the global population matter? (not depicted here)
b) Asymmetry of victims (different species are affected)		

i) 	Entities of nature affected by the conservation action are attributed different intrinsic or instrumental values to those affected by environmental change if nothing is done. Contrary to the original trolley problem, the depiction shown here assumes that an action aimed at conserving a valuable entity of nature will lead to the death of multiple, less valuable entities.	• How should entities of nature with different values (intrinsic or instrumental) be compared?
ii) 	In reality, conservation actions affect whole communities or assemblages—each track contains multiple different entities of nature, and the entities have different values attributed by different stakeholders, and impact different numbers of individuals per species.	• How should whole assemblages be compared recognising different stakeholders will likely have different value systems?
c) Asymmetry of impacts		
	In this case the trolley will cause several animals to suffer but not kill them (the trolley knocks animals from the track, hurting them in the process). If the lever if pulled a single animal is killed.	• How is impact measured? • How are different impact magnitudes compared? (e.g., death vs. suffering)
d) Spatial and temporal asymmetry		

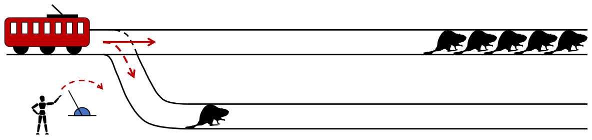
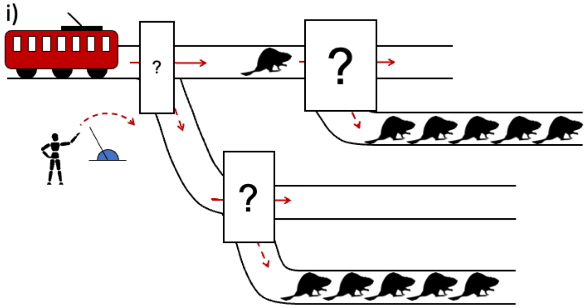
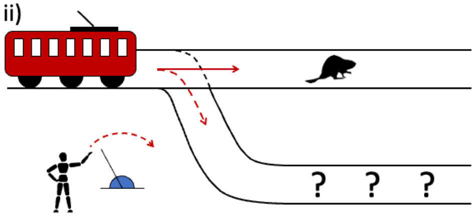
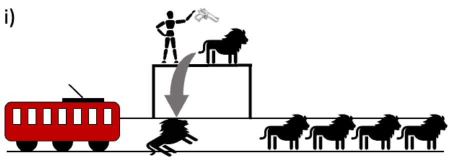
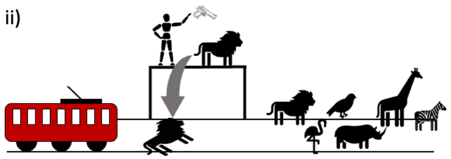
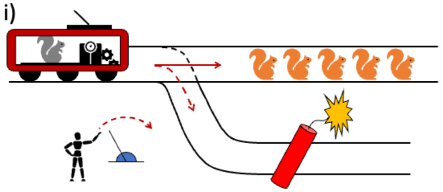
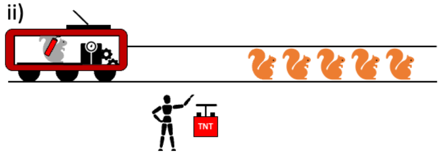
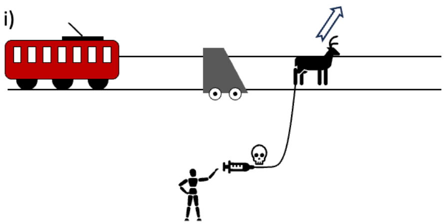
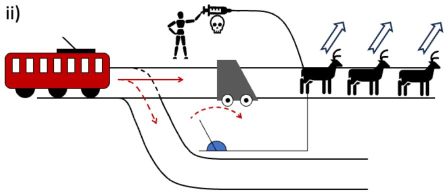
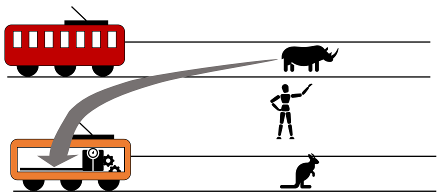
	The consequences of an action has an effect distant in time or in space. In the metaphor, temporal and spatial remoteness are indissociable, as individuals further in space will be impacted further in time, but not necessarily in the real world.	• How should impacts that occur in the future be compared with impacts that occur immediately? • How should impacts that occur in different places be compared?
e) Uncertainty and unforeseen consequences variation		
i)  ii)  	Conservation actions are usually made with some urgency but based on imperfect information and often inherent uncertainty as to the outcomes. In terms of the trolley problem metaphor this can be represented by: i) making the path of the trolley towards one set of tracks or another uncertain (question marks in boxes); or ii) by uncertainty about which entities are present in which abundances (question marks on the tracks).	• How should uncertainty around impacts affect conservation decisions? • What is the relative importance placed of maximising benefits and minimising risks?

Table 3. List of variations of the trolley problem for real-world conservation issues involving different relationships between the presence of an individual and the death of others, and different levels of involvement of stakeholders.

Trolley problem variations for conservation	Short description	Raised issue(s)	Real-world example
a) Trophy hunting			
i) 	Similar to the original "giant on a bridge" variation. Killing an animal will make it fall on the tracks and stop the trolley, preventing the death of others. The moral agent is therefore actively involved and thus takes personal responsibility in sacrificing a conservation target.	Is it acceptable to kill an individual to save others, although this individual is not involved in the future death of the others?	Trophy hunting is used in 23 African countries (Lindsey et al., 2007). It generated many debates both in the philosophical realm and on social media (Bichel and Hart, 2023). A famous example of such debate surrounded the killing of Cecil the Lion (Nelson et al., 2016).
ii) 	To be closer to a real-world application, the animals saved may belong to multiple species; and the both the hunter and the people facilitating the hunting derive some benefits (not shown).		
b) Biological invasions			

i) 	The option is to pull a lever, but not directly kill an animal (which will nonetheless die). This is similar to “the giant on a loop” variation, but the difference is that the presence of the animal in the trolley leads to the death of other animals.	• Is it acceptable to kill an individual to save others if this individual is the reason others will die? • Does the way an individual dies affect the decision? • Does the degree of involvement by stakeholders affect how the options are viewed? • Does the reason for the invasive species being in the trolley affect the decision? e.g. why and by whom the species was introduced in the first place (not shown).	The grey squirrel (*Sciurus carolinensis*), native from North America, is invasive in Europe, where it threatens the native red squirrel (*Sciurus vulgaris*), but its lethal controlled has been challenged in some places by the general public, including legal actions by animal right activists in Italy (Genovesi and Bertolino, 2001).
ii) 	The option is to directly kill the animal in the trolley. This is similar to the giant on a footbridge variation, but as above, the difference is that the presence of the animal in the trolley leads to the death of other animals.		
c) Species culling			
i) 	An animal will be hit by the trolley and suffer greatly but not necessarily die (or will die later). There is an option to inject a lethal and non-painful poison to kill the animal before it is hit by the trolley.	• Is it acceptable to kill an individual to prevent its long-term suffering? • Are death and harm comparable?	Following the reintroduction of large herbivores to the Oostvaardersplassen Nature Reserve for rewilding purposes, culling was implemented to reduce suffering in winter—the public felt letting animals starve

ii) 	A trolley is heading towards multiple animals, and will injure them greatly. The bifurcation mechanism is linked to the vital rates of one of these animals. The options is to inject an animal with a non-painful, lethal poison, so that its death diverts the trolley towards empty tracks.	Is it acceptable to actively kill an individual to save others, acknowledging this individual and the others would be harmed or killed otherwise, but by another process?	was unacceptable (ICMO2, 2010).
d) Species relocation			
	Saving an entity of nature sets a trolley in motion, leading to the death of another entity.	Should we save an entity if this entity will then cause the death of another individual, either directly or indirectly?	Species relocation has been advocated to conserve endangered species (Hoegh-Guldberg et al., 2008). These have raised concerns given the risks to impact other species (Ricciardi and Simberloff, 2009), for example the introduction of endangered rhinoceros in Australia (Hayward et al., 2018).

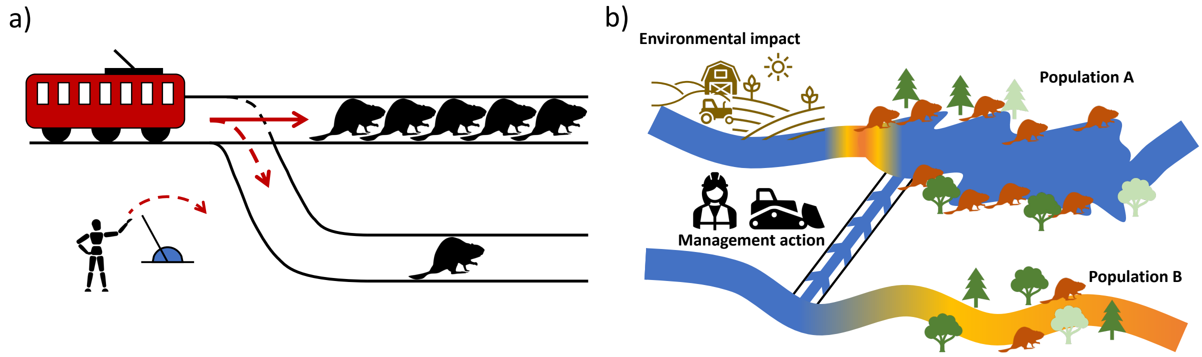


Figure 1. The trolley problem applied to conservation. a) In the original version, entities of nature are attributed the same intrinsic or instrumental value, here individuals of the same species. The tracks represent two conservation management options: the upper tracks are a *laissez-faire* option that will lead to many individuals being harmed, whereas the lower tracks represent the implementation of a management action that would lead to fewer individuals to be harmed, but those would not have been harmed without the action. Note that the individuals on the two tracks belong to different populations, and that the population on the second track is not a subset of the first one. b) A framing of the trolley problem in a conservation context. A large population of beavers is affected by anthropogenic activity that cannot be prevented. Diverting water from a nearby river would save them, but lead to the death of a distinct, smaller beaver population.

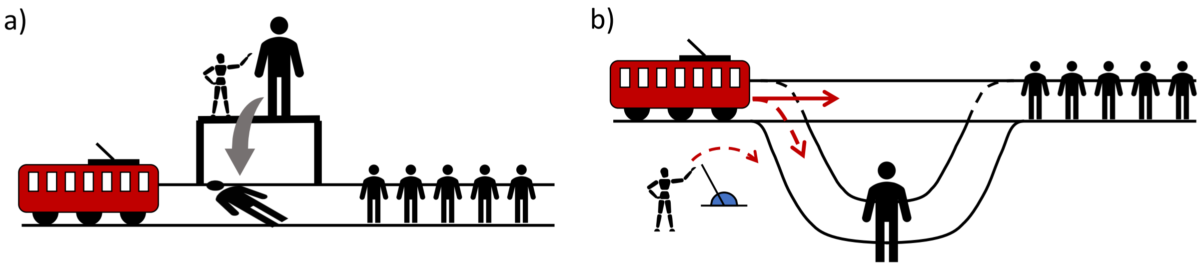


Figure 2. Two variations of the trolley problem in which the intentionality of actions differ. a) The original “giant on a footbridge” variation from Thomson (1976), in which the trolley can be stopped by pushing a giant onto the tracks. b) The “giant on a loop” variation, in which the giant is stuck on a loop to which the trolley can be diverted (Singer, 2005; Thomson, 1985). In both cases, killing the giant will end up preventing the death of the five people, but this is achieved through different actions, whose nature may determine if an action is acceptable or not under different normative perspectives. Different conclusions would suggest that the nature of the action is important rather than how the giant is “used”, which would refute the principle of double effect. People’s may also react differently to the two variations due to emotional connections to the action to be taken.

Supplementary material for: “Ethical dilemma in conservation: a trolley problem thought experiment”

Appendix S1. Unresolved conflicts between conservation approaches

Traditional vs new conservation. Traditional conservation as defined by Soulé (1985) follows an ecocentric perspective, based on the following normative postulates: (i) diversity of organisms is good; (ii) ecological complexity is good; (iii) evolution is good; and (iv) biodiversity has intrinsic value. By contrast, new conservation argues that maximising biodiversity can only be achieved through a utilitarian perspective (Kareiva and Marvier, 2012). That is, even if they do not argue against the intrinsic value of biodiversity, proponents of new conservation consider that many stakeholders follow a utilitarian perspective, and that designing conservation actions aiming at preserving species with instrumental values is the most effective approach for conserving biodiversity. This position has been heavily criticised by some proponents of traditional conservation, and clarifications from new conservationists have not allowed to settle the argument (see e.g. Doak et al. 2015; Kareiva and Marvier 2012; Soulé 2014, for different perspectives).

Traditional vs compassionate conservation. Compassionate conservation is a recent approach that is based on virtue ethics and promotes actions that stem from a compassionate attitude, following four tenets: i) do no harm; ii) individuals matter; iii) inclusivity (the value of an individual is independent from the context of the population, e.g. nativity, rarity, etc.); and iv) peaceful coexistence (Ramp and Bekoff, 2015; Wallach et al., 2018). Compassionate conservation opposes the killing of sentient animals regardless of context, e.g. when an invasive species or a native predator threaten other native species due to ecological imbalance resulting from anthropogenic change (Wallach et al., 2018). Compassionate conservation generated heated responses from traditional conservationists (e.g., Driscoll and Watson, 2019; Hampton et al., 2018; Oommen et al., 2019), and subsequent responses (e.g., Wallach et al., 2020) have not convinced opponents about the approach.

Compassionate conservation vs conservation welfare. Conservation welfare is a consequentialist approach that aims to minimise animal suffering in conservation (Beausoleil et al., 2018). It therefore shares a focus on animal sentience with compassionate conservation (although compassionate conservationists have contradicted themselves in the literature, mentioning both the importance of considering individuals’ joy and pain, while at the same time advocating for considering all wildlife regardless of sentience; Wallach et al. 2018). Conservation welfare provides an objective criterion to determine the appropriateness of a conservation action (assuming suffering can be objectively measured). By contrast, compassionate conservation does not provide clear guidelines to determine what makes a conservation action guided by compassion beyond avoiding lethal actions, and how, for example, to resolve situations where lethal control would decrease overall suffering (Beausoleil, 2020). Thought experiments depicting specific but hypothetical ecological situations were described by Rohwer and Marris (2019) as a basis for clarifying the stance of compassionate conservationists, but obtained no response, to our knowledge.

Appendix S2. Avenues to combine trolley problem variations and apply it to conservation issues

Conservation partners and stakeholders or proponents of different conservation approaches driven by normative theories may disagree over a conservation action for different reasons, which can be difficult to pinpoint exactly, leading to further conflict and frustration. Here we suggest an approach to combine the different variations of the trolley problem presented in this paper in a systematic fashion, to explore which aspect of the action generates opposition. The trolley framing by itself will not solve conflicts, generate practical actions or create consensus; rather, it is meant as a diagnostic step to facilitate dialogue and clarify potential for conflict resolution. In addition, framing the issue using the trolley metaphor may present the issue to stakeholders in a different light, raise understanding of other stakeholders' value systems, leading to a change in their stance or how strongly they feel about it. In addition, other combinations of variations may be appropriate for specific situations. Ideally, this process would be embedded in a broader structure for rational decision making, such as systematic conservation planning, structured decision making, or open standards for the practice of conservation (Schwartz et al., 2018).

Framing. The first step is to clearly define the action being discussed, as well as its spatial and temporal scale and scope. One should identify the decision makers, stakeholders and partners involved. The objective(s) of the action should be absolutely clear to all involved: these define what goes on the tracks of the trolley scenarios, that is, the entities being considered and how they are represented/quantified. A model of the system is necessary to fill in the problem with the different outcomes, that is, the individuals/entities that die in the different scenarios, and any other relevant objectives.

Variations. The original trolley problem is unlikely to capture the realistic conditions of the real-world problem at hand. Therefore, the group should develop a set of variations to explore the influence of different aspects. It is important here to strike a balance between realism and abstraction: overly complicated problems may become less and less informative as a diagnostic. If divergences or conflicts remain when the most complex version of one element is built, it indicates that other elements are important, and one can move to the next (for example, from involvement to uncertainty).

Involvement. Develop a set of trolley problem variations with increasing direct involvement of stakeholders in the death of the entity, until most elements from the real situation are captured (Figure S1a). The last variation of the phase 1 of the framework should be the closest to the concrete situation in terms of causal relationships between species' life and death and of stakeholder involvement. For example, lethal management of invasive species is often recommended in early stages of invasion, when eradication is still possible (Pluess et al., 2012), usually implying active killing of individuals. In the context of invasive species management, one can therefore investigate if stakeholders have different stances about the indirect and direct killing of individuals, which would correspond to environmental management vs. lethal approaches, and the impacts these individuals have on others (Figure S1a).

Asymmetry. To explore additional components, one should progressively add different species that may be affected by the choice and discussing their values (asymmetry of victims), different types of impacts including lethal and non-lethal (asymmetry of impacts), and different spatial and temporal scales at which impacts will be realized (spatio-temporal asymmetry) (Figure S1b). For example, will lethal trapping of invasive species incur by-catch of native species, including common or endangered ones? Would the removal of invasive species cause suffering in the immediate future, but avoid larger impacts in the longer term, or at a larger scale?

Uncertainty. Given the nature of conservation problems, capturing some level of uncertainty will likely always be necessary. In this case, the trolley representation might be modified to reflect a decision tree (Canessa et al., 2016), for example by choosing a small set of scenarios with possible (uncertain) outcomes to discuss, represented by different tracks (Figure S1b). This uncertainty should ideally come directly from the model of the system used to represent the outcomes of the action in the original problem description. For example, one could represent different velocities of spread by the target invasive (represented by different levels of impact on native species) or different levels of by catch by untested removal methods. The different scenarios can initially be described verbally, and if needed then associated with their different probability of occurrence.

Combining variations. Finally, if no change of opinion still arises, we recommend combining these variations in phase 3 (Figure S1c). How to combine these variations will likely be context dependent.

Discussion. Depending on the sensitivities, one may need to adopt different facilitation methods to lead stakeholders and groups through the process. Ideally, best practice methods for dealing with groups, including a careful composition of groups. To avoid dominance and power dynamics, as well as common heuristics such as anchoring, discussions should always allow adequate space for individual, anonymous judgments (Sutherland and Burgman, 2015). Note that the ultimate goal should be to clarify the causes of disagreements, not necessarily to achieve consensus, particularly where fundamental value differences exist.

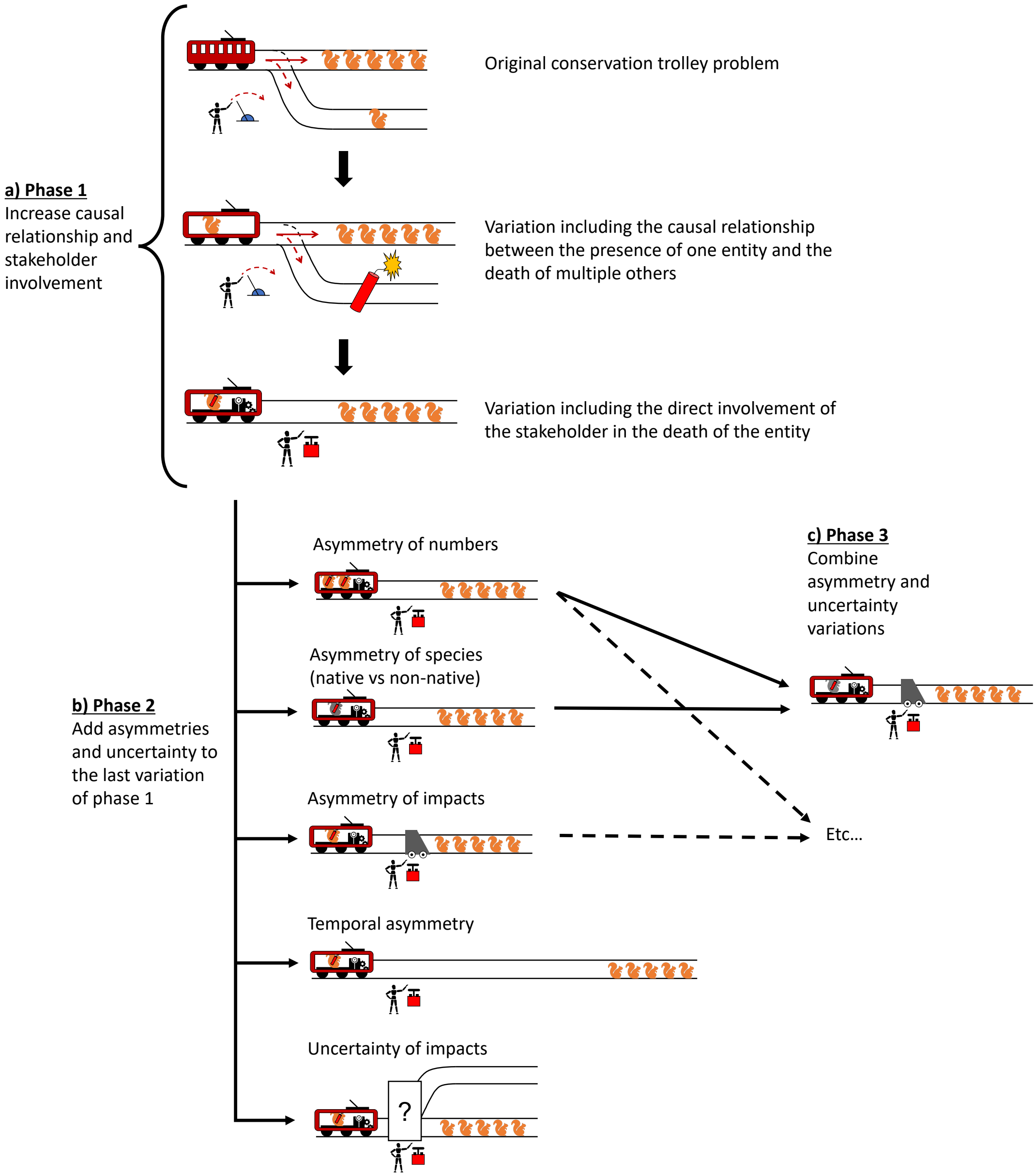


Figure S1. Three-phase framework for combining conservation trolley problem variations and detecting the source of conflicts of opinion or dilemma about conservation actions, using an invasion by the grey squirrel (*Sciurus carolinensis*), native to North America and introduced in various locations in Europe during the late nineteenth and the twentieth century, now threatening the native European red squirrel (*Sciurus vulgaris*) (Bertolino, 2008). a) Phase 1 starts with the original conservation trolley problem, and variations are then designed to consider the relationship between the presence of an individual and the death of other squirrels (here using the variations presented in the main text for invasive alien species). Note that at this stage, we do not differentiate between species, as the goal is to examine if causal relationships are at the origin of the conflicts, while excluding potential differences in value. In the figure, subsequent variations incorporate the fact that one individual is responsible for the death of others, and that it is killed as a side effect of saving the others (e.g. through the management of the environment - first variation), and that it is killed directly (lethal control - second variation). b) In phase 2, the last variation of phase 1 is used as a basis to incorporate different elements of asymmetry and uncertainty. c) In phase 3, the variations from phase 2 are combined iteratively.

Appendix S3. Stakeholders as part of the system

In the variations and examples above, we only compared choices where stakes were directed at non-human entities of nature. In practice, conservation decisions will often also affect human beings. For example, the introduction of non-native species is often linked to economic interests (directly when benefitting from the introduced species themselves or indirectly from general trade when non-native species are transported as stowaways or contaminants). Thus, preventing the introduction of non-native species may have economic impacts such as foregone revenue from harvesting the non-native species or from causing additional economic costs for biosecurity or reduced trade volume.

The inclusion of humans into these dilemmas (Figure S2) will likely affect decisions. The difference in intrinsic value that is attributed to humans vs non-humans is likely to be incommensurable for many people. Reciprocally, monetary benefits that may be drawn from some environmental change may be considered irrelevant compared to animal life. Tetlock et al. (2000) and Schwartz (2021) distinguish between ‘sacred ‘and ‘secular’ values in conservation. For sacred assigned values, such as human life, compensation for their loss is impossible, while loss of secular assigned values could be compensated. If pitting entities with secular values against each other is a common issue in everyday life (‘regular choice’ hereafter), pitting entities with sacred and secular values (referred to as taboo trade-offs, or taboo choices) can be perceived as undercutting self-image and social identity as a moral being, and generate negative cognitive, emotional, and behavioral reactions from actors facing such decisions (Fiske and Tetlock, 1997). By contrast, “tragic choices” pitting entities with sacred values against each other and for which no option is satisfying, are deemed more acceptable than taboo choices, and even virtuous by people (Schoemaker and Tetlock, 2012). As the type of value (sacred or secular) attributed to different entities of nature can vary between people, different stakeholders may face regular, tragic or taboo choices, potentially leading to conflict.

When secular goals have a wider or long-term effect on entities with sacred values, taboo choices may be reframed as tragic choices, potentially facilitating discussion and exchange (Daw et al., 2015). For example, impacts on non-human species and the environment can be linked to current human livelihood and that of future generations. Finally, the fact that choices may impact decision makers themselves or not (Figure S2a,b) may add another level of complexity to the dilemma.

Environmental deterioration is often linked to economic benefits (e.g. mining activities typically have negative environmental impacts but generate jobs, resources, and profits). We have focused on choices between negative outcomes, which is naturally captured by the original trolley problem. Benefits (including offsets) could be easily incorporated in the conservation trolley problem by suggesting to receive money or another reward for rerouting the trolley towards an entity (Figure S2c). Assuming the reward has a secular value, the nature of the dilemma will then depend on if the non-human entities of nature that are being impacted have a secular value (regular choice) or a sacred one (taboo choice) for the decision-makers and stakeholders.

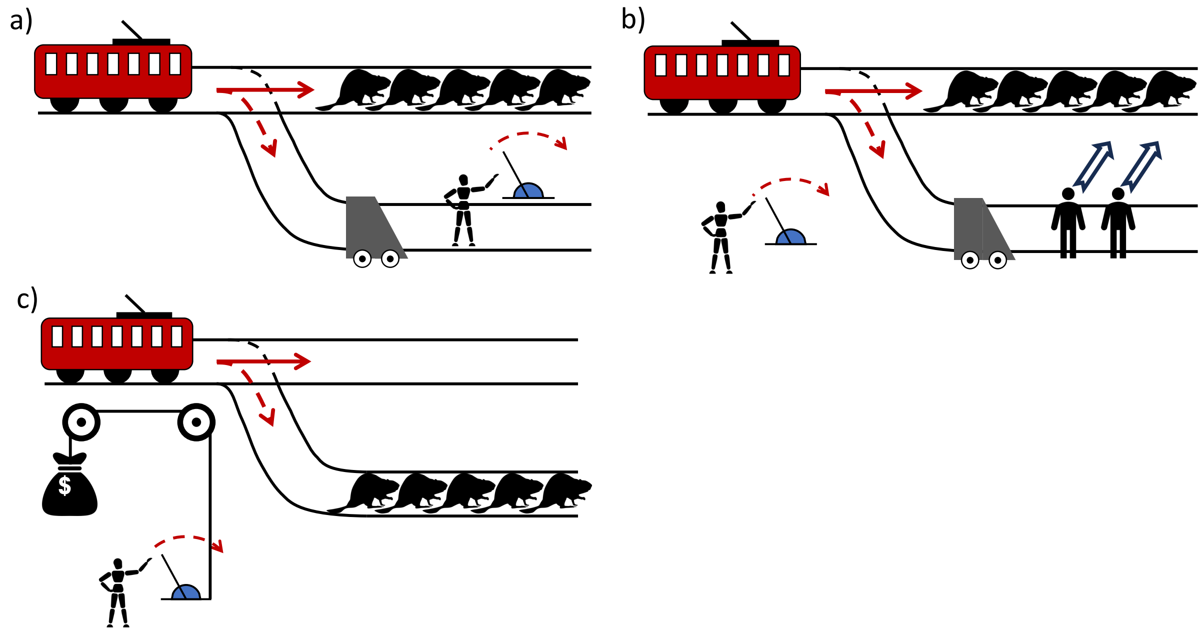


Figure S2. In some situations, management actions will affect stakeholders, negatively or positively. Negative impacts will usually not be lethal, and with some uncertainty, but may affect welfare, for example, when access to some areas is restricted. a) Decision makers can be directly affected by their decision. b) The decision may affect other stakeholders than the decision makers. c) There can be positive consequences, such as profits or other rewards, associated with negative impacts on non-human entities. Depending on how values attributed to non-human entities, stakeholders, and rewards may differ from one another (have a secular or sacred value), this can lead to regular, taboo or tragic choices.

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