Hedgehogs in Britain threat analysis report

April 2023

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Executive summary

Hedgehogs are a popular species within Britain, gaining wide public concern and interest. However, they benefit from only limited legal protection at present and face multiple, interacting threats. The threat analysis conducted to produce this document brought together a subset of stakeholders working directly with the species to identify what is known and thought to be known about the reasons the decline in hedgehogs in Britain.

Twenty-three direct threats (i.e., those factors identified to have a direct, negative impact on hedgehogs) were identified in this workshop ranging from those explicitly linked to hedgehog deaths (e.g., vehicle collision) to more chronic impacts, such as the potential consequences of toxin accumulation. Threats such as reduced food availability and nesting/hibernation sites were perceived to compromise hedgehog reproduction as well as leading to elevated mortality.

A preliminary threat ranking exercise firmly identified increased vehicle collisions, decrease in available food, lower hibernation survival rates, toxin accumulation, and needing to travel further for food as top priority threats for hedgehogs in Britain. Some of these threats (e.g., road accidents and decrease in food) have a relatively decent evidence base, whereas others (e.g., lower hibernation survival and toxin accumulation) have seemingly little data available to support them. The preliminary threat ranking exercise also identified differences of opinion on the importance of threats such as entanglement in litter, genetic isolation, and reduced access to water (driven by climate change). This preliminary ranking assessment will provide a useful starting point for wider discussions at the strategic workshop at the end of April 2023. It also provides a basis for identifying the most significant knowledge gaps and so inform research priorities.

The direct threats identified in this threat analysis do not exist in a vacuum and are driven by multiple indirect threats (e.g., supplementary feeding and increased transport infrastructure) that, in turn, are driven by a variety of overarching factors (e.g., agricultural intensification and climate change). The number of drivers for each direct threat vary and thus the pathways to each direct threat vary in complexity. The threat diagrams presented in this document analysis are intended to demonstrate this variance in complexity and the multiple points where action could be taken to mitigate a given threat to hedgehogs.

The scale of the threats facing hedgehogs within Britain varies geographically and temporally. The status of rural populations is especially concerning as monitoring does suggest that hedgehogs in rural landscapes are faring worse than their urban relatives. Roadkill extrapolations indicate a potentially significant impact on hedgehogs, particularly compounded by the effects of reductions in foraging and nesting habitats through temporal land use changes in both rural and urban environments. The socio-economic push for more housing, busier and extended road networks, intensification of agriculture, are likely to put the species under increasing pressure if no coordinated, strategic action is taken.

The broader system

Based on an analysis of the wider socio-political and economic system surrounding hedgehogs in the UK, members of the Organising Team for this planning process identified a range of factors that could impact the species both positively and negatively.

Socio-political factors

The hedgehog is a popular species within the UK and so policies that support the species are likely to receive a favourable response from the general public. Growing public awareness of climate change and the steep decline in biodiversity is also contributing to a general sense of a need to care for the environment and promote more sustainable/ wildlife-friendly behaviours. Conversely, current government moves to reduce 'red tape' surrounding environmental protection legislation could pose a threat to the hedgehog as with other species and there appears to be a current lack of political will to provide the species with more legal protection.

Negative media publicity regarding potential zoonoses (even if misinformed) can quickly destroy public tolerance of hedgehogs (recent examples: Salmonella, MRSA, SARS-CoV2). Further misinformation shared about the ecology, feeding, rescue, and care of hedgehogs on social media could hamper priority conservation efforts for the species. Further, the popularity of species can lead to anthropomorphism resulting in misrepresentation and unnecessary interventions.

Economic factors

Despite ongoing austerity measures, the UK remains a relatively wealthy country and - if prioritised - would be in a position to provide more resources to support national wildlife conservation efforts. Hedgehogs themselves are a useful fundraising poster-animal, at least for animal welfare organisations and conservation charities working with the species. This may be an opportunity that could be further capitalised upon to support conservation efforts.

The drive for more infrastructure and housing stock both now and in the future poses a potential threat to hedgehogs and suitable habitat for them to occupy. The ongoing housing crisis coupled with elections in 2024 could result in a massive increase in housebuilding without good public transport links and therefore requiring significant associated road-building, car use and habitat loss. New housing also often lacks garden space designed to promote wildlife, instead providing overly sterile environments. The lack of legal protection for the species reduces the impetus to undertake research on it, and so research efforts tend to fall to charities to fund. Concern for other species over the hedgehog (e.g., as illustrated by significant investment to remove them from the Western Isles of Scotland) pushes the species further down the list of priority species to support.

Technological

New technology is making it easier and more effective to monitor and track hedgehogs and so fill important knowledge gaps on the species. Forthcoming research on hedgehog genetic structure and monitoring studies in Great Britain could address knowledge gaps in hedgehog ecology.
Wildlife programmes using some of this technology (e.g., BBC Spring Watch) provide a powerful public awareness and engagement tool. Social media platforms create opportunities for correct information sharing and for getting the public involved in data collection ('citizen science'). The move towards low emission vehicles could present a benefit to hedgehogs, as for other wildlife, due to lower levels of toxins in the air and decreased contributions to climate change. Technological advancements mean that more people spend time in the 'virtual world' potentially providing a disconnect with the natural world. Some technologies can also be directly harmful to hedgehogs, e.g., some designs of robotic lawnmowers. Many others, such as ultrasonic rodent/cat scarers, are unevaluated.

Legal/ Policy factors
Hedgehogs do benefit from some limited legal protection under Schedule 6 of the WCA (1981) and the Animal Welfare Act 2006. However, there is no protection in law for nesting sites. Full protection under Schedule 5 has been considered, but it is unclear how it would be beneficial in practice. It would likely require surveys to be undertaken by developers, but how useful/practical are these for finding hedgehog nests and protecting them?

There is no regulation of the animal welfare sector in England and Wales and no legislation to control the translocation of displaced wildlife in the UK except for species listed in Schedule 9 of the Wildlife and Countryside Act and the Invasive Species (Enforcement and Permitting) Order 2019. Currently, there appears to be conflicting advice coming from the Royal College of Veterinary Surgeons (RCVS) and the Veterinary Medicines Directorate (VMD) with the RCVS having more stringent advice on the prescription of antimicrobials, stipulating that a physical exam by a vet is requited before prescription while the VMD pushes for the ability for vets to prescribe remotely. Changes to RCVS regulations around prescribing (especially of antimicrobials) and the Veterinary Medicines Regulations (VMRs) at the end of 2023 may control poor prescribing practices for certain medicines when hedgehogs are taken into care facilities without an in-house vet, but may also drive such care facilities to seek out antimicrobial drugs online.

Environmental factors
The generalist nature of hedgehogs does make it easier to provide suitable habitat for the species to thrive in. Agri-environment schemes and 're-wilding' projects present opportunities for further habitat creation and better connectivity between existing habitat to be established. However, further reductions in habitat availability and quality are likely due to changes in agricultural intensification. Lack of hedgerow management can cause hedges to degenerate in quality, and intensification in terms of sustained of increase chemical use, heavy machinery that compacts soil, and increased cropping are all likely to decrease food availability for hedgehogs. Modern garden design is also likely playing a negative role. Changes being made currently to agri-environment policy may lead to uncertainty in the short to medium-term, especially given the lack of detail currently being shared publicly on these policy updates, which could lead to decreased uptake by landowners.

There is good evidence of the impact of the busy road network on hedgehog mortality, though the lack of solid evidence of the impacts of other perceived threats to the species, at a population level, hamper efforts to challenge current practices in both the rural and urban environment. It is, for example, difficult to disentangle the possible lethal and sub-lethal effects of the numerous environmental pollutants found in hedgehogs (e.g., heavy metals, flame retardants, PCB's, agrochemicals and rodenticides). Lastly, the relationship between hedgehogs and badgers is a sensitive issue and research findings need to be interpreted with care. Clear, evidence-based messaging is therefore particularly important to avoid "demonising" badgers.

Although it is difficult to predict the impacts of climate change on hedgehogs, it does result in rapidly changing weather patterns, with increasing periods of drought. This is likely to lead to further food reduction (e.g., earthworms or slugs) available during summer months. Also, increasingly wet winters result in frequent flooding and risk of drowning during the winter hibernation period.

Threat analysis results

Top-level results
The threat analysis exercise centred on understanding the causes behind the overall decline in the hedgehog population, with three proximal drivers linked to that decline: Reduced fitness (e.g., decreases in health, survival, recruitment into the adult population), increased mortality, and lower density of populations (although lower density of populations could be considered to be very similar if not the same as a decline in hedgehog populations and may not warrant listing as a separate proximal driver). Through the threat analysis process, we identified overarching factors hypothesised or known to be linked to hedgehog population decline, the effects of those overarching factors, and how those effects fed into the proximal drivers of decline. Based on this exercise, we produced a large, interlinked causal flow diagram (Appendix Figure A1.1)

We used this causal flow diagram to identify 23 direct threats to hedgehogs in Britain. These are threats that directly feed into one or more of the proximal drivers of decline (Figure 1) and are the threats that will be focussed on during the strategic workshop.

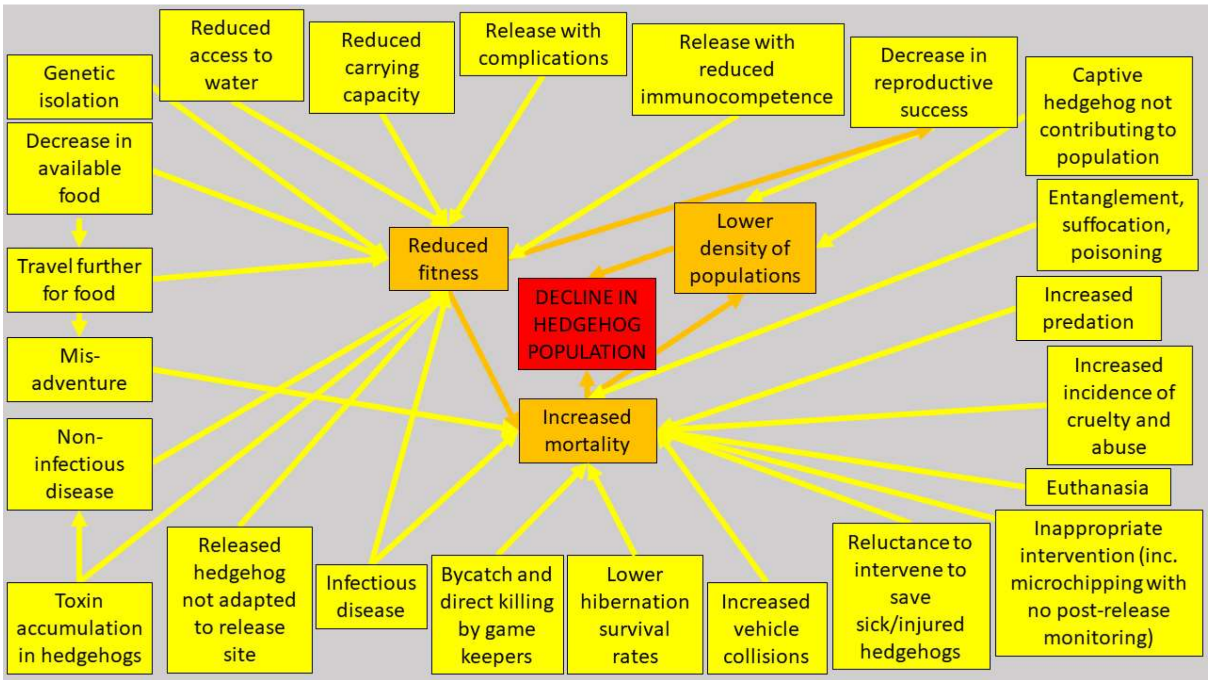

Figure 1: Direct threats (yellow boxes) identified in hedgehog threat analysis workshop that lead to proximal drivers of decline (orange boxes). Note that some direct threats lead to other direct threats as well as to proximal causes of decline. Colour of arrows reflects the type of box the arrow is coming from.

Each of these direct threats is linked to a series of indirect threats and challenges, which themselves link back to the overarching factors affecting hedgehogs in Britain. For each direct threat, we have created a mini causal flow diagram that shows all the indirect threats and overarching factors that feed into that direct threat (Appendix Figures A2.1-A2.23). Note, overarching factors are defined as top-level factors that do not have any links feeding into them (e.g., climate change). The purpose of the mini diagrams is to illustrate the range in complexity of the factors leading into each direct threat, identify common themes and/or redundancy between threats, and to aid discussion of each threat during the strategic workshop.

Threat analysis breakdown

It is clear from the causal flow diagram created at the threat analysis workshop (Figure A1.1) that the known/perceived threat landscape for hedgehogs is complex, with numerous links and interactions between direct and indirect threats. However, when the direct threats are broken down into individual mini causal flow diagrams, patterns and themes start to emerge.

The mini causal flow diagrams range in complexity from a simple chain of one single factor leading to a direct threat (e.g., Figure A2.4 “Reduced access to water”) through to much more complicated scenarios with multiple interlinked direct and indirect threats stemming from multiple overarching factors (e.g., Figure A2.1 “Decrease in available food). Categorising direct threats by complexity based on these diagrams (Table 1) is potentially helpful for prioritising direct threats or working through potential actions to mitigate direct threats during the strategic planning process.

A relatively simple causal flow diagram does not necessarily mean a direct threat is simple to mitigate, however. The direct threat, “reduced access to water” has just one link, which is back to climate change. If climate change is the only thing driving this threat, then this is not a particularly easy direct threat to mitigate as climate change is a much bigger issue in its own right. A simple mini causal flow diagram could also indicate a lack of knowledge/data/understanding of additional links to that direct threat.

Table 1: Direct threats categorised by the complexity of their respective mini causal flow diagrams.

Direct threats with “simple” mini causal flow diagrams	**Figure**
Reduced access to water	A2.4
By-catch and killing by game keepers	A2.5
Release with complications	A2.11
Decrease in reproductive success	A2.12
Increased vehicle collisions	A2.17
Reluctance to intervene to save sick/injured hedgehogs	A2.18
Entanglement/suffocation/poisoning	A2.21
Low hibernation survival rates	A2.22
Direct threats with “medium” complexity mini causal flow diagrams	
Non-infectious disease	A2.7
Toxin accumulation	A2.8
Reduced carrying capacity	A2.10
Decrease in reproductive success	A2.12
Inappropriate intervention	A2.13
Euthanasia	A2.14
Increased predation	A2.20
Captive hedgehogs not contributing to population	A2.23
Direct threats with “complex” mini causal flow diagrams	
Decrease in available food	A2.1
Travel further for food	A2.2
Misadventure	A2.3
Genetic isolation	A2.6
Infectious disease	A2.9
Released with reduced immunocompetence	A2.15
Released hedgehog not adapted to release site	A2.16
Increased potential for cruelty/abuse/accidents	A2.19

Examining the direct threats categorised as having “complex” causal flow diagrams, it becomes clear that threats connected to food, disease/injury, releases, and genetic isolation have the most complex network of threats and interactions between threats. However, some of these are also the least studied areas with little data (as yet) to define exactly what degree of impact these direct threats are having on hedgehog declines in Britain.

Two particular indirect threats, “Hedgehogs with vets/in rehab” and “Supplementary feeding” appear in more mini causal flow diagrams than any others. “Hedgehogs with vets/in rehab” (seven and six diagrams respectively). The only diagram where both these threats appear is that for the direct threat of “Infectious disease” (Figure A2.9), which is, as a result, a relatively complex diagram. “Hedgehogs with vets/in rehab” also has six direct threats that feed into it (“Entanglement, suffocation, poisoning”, “Infectious disease”, “Non-infectious disease”, “Increased potential for cruelty/abuse/accidents”, “Misadventure”, and “Increased vehicle collisions”). “Supplementary feeding”, on the other hand, has no direct threats feeding into it, but five overarching factors, all of which are sociological. The fact that the two indirect threats “Hedgehogs with vets/in rehab” and “Supplementary feeding” appear in connection with multiple direct threats connected to food, disease, and injury at least partly explains why these particular direct threats have such relatively complex mini causal flow diagrams.

The indirect threat “Habitat fragmentation” only feeds into two direct threats, “Travel further for food” (Figure A2.2) and “Genetic isolation” (Figure A2.6). However, like “Hedgehogs with vets/in rehab” and “Supplementary feeding”, the connections into “Habitat fragmentation” (both in terms of indirect threats and overarching factors”) are numerous and interlinked, so much so that “Habitat fragmentation” required its own separate mini causal flow diagram (Figure A2.6 insert).

The mini causal flow diagrams can also be used to identify which direct threats are primarily urban, which are features of rural landscapes, and which are both. For example, the direct threat “Travel further for food” (Figure A2.2) features both urban and rural overarching factors, “Bycatch and direct killing by gamekeepers” is purely a rural issue (Figure A2.5), and “Entanglement, suffocation, and poisoning” (Figure A2.21) appears purely urban (although this is debatable as litter, the indirect threat feeding into this direct threat, also occurs in rural landscapes).

The last point above indicates some of the actions required either prior to or during the strategic management workshop. When broken down by direct threats, it becomes clear that there are some missing links in certain diagrams (such as rural litter mentioned above) and that there is potentially also some redundancy in the diagrams. For example, the diagram for direct threat “Release with complications” (Figure A2.11) could potentially be folded into the diagram for “Inappropriate intervention” (Figure A2.13) without the loss of substantial information.

Evidence-base for threats

Another important consideration in moving from the threat analysis to a strategic workshop is understanding which of the direct threats there is a good evidence-base for, and which serve to identify knowledge gaps where more work is needed. An evidence collation exercise was initiated towards the end of the threat analysis workshop and then continued in the months following the workshop with the assistance of the organising team and worked up into a narrative summary (see Appendix 3). Table 2 illustrates how the results of this evidence collation exercise relate to the direct threats identified via the causal flow diagram.

Table 2: Direct threats with available evidence to support them having a negative impact on hedgehogs in Britain. Blank spaces in the "Evidence to Support" column do not necessarily indicate an absence of evidence for that threat, but show that no evidence has yet been identified as part of the threat analysis exercise. For references in this table, see the References section at end of Appendix 3.

Direct threat	**Figure**	**Evidence to support**
Decrease in available food	A2.1	Macro-invertebrate declines across England (e.g., see Ball *et al.,* 2021; British Ecological Survey, 2022; Hoff and Bright, 2010b). It is assumed that the presence of pesticides has an impact on hedgehog food and subsequently directly on their health and indirectly through reducing food availability. The total abundance of larger moths caught in Britain decreased by 33% over 50 years (1968–2017): Southern half of Britain (39% decrease); northern half (22% decrease). Forty-one percent (175) of the species studies had experienced declines over this period (Fox *et al.,* 2021). We also know that pesticides are used widely in agriculture and in amenity areas. Arable fields with grassy margins help increase the availability of a particular hedgehog prey species- such as earthworms (Hof and Bright, 2010b). Recent research carried out by BTO shows a significant and long-term decline in earthworm abundance in the UK, a key prey item of hedgehogs, with associated declines in bird species which feed primarily on them such as thrush and starlings (Barnes *et al*., 2023)
Travel further for food	A2.2	Another issue associated with intensification and mechanisation is field size and scale of the landscape. Hedgehogs seem to do better in small-scale agricultural landscapes (Huijser, 1999). The availability of field margins and associated hedgerows does seem to provide protection from predators for hedgehogs as they move through the landscape (Hof *et al.,* 2012).
Misadventure	A2.3	Injury through strimmers and (robotic) lawnmowers, dog attacks, drowning in swimming pools and ponds, burning in bonfires, falling down holes (e.g., uncovered drains) and outdoor cellars and outdoor 'light boxes' (designed to let

		light into downstairs rooms – e.g., velux sun-tunnels https://www.velux.co.uk/products/sun-tunnels) are all known to be causes of injury and mortality to hedgehogs. Given the abundance of the species within urban settings, such threats are likely to remain, though there is no evidence that they are having population level negative impacts.
Reduced access to water	A2.4	
By-catch and killing by game keepers	A2.5	
Genetic isolation	A2.6	Evidence from genetic and movement studies indicate that the population is fragmented (Moore *et al.,* 2020), and that they seem to be avoiding roads in some instances. In a study in Denmark (Rasmussen *et al.,* 2023) inbreeding did not appear to affect the lifespan of hedgehogs studied. In one modelling study (Moorhouse *et al.,* 2014), doubling the total length of hedgerows predicted substantially enhanced connectivity for the species. Becher & Griffiths (1998) found highly significant levels of genetic differentiation between closely-spaced rural populations of hedgehogs in Oxfordshire. This genetic isolation was not associated with distance between sites, suggesting that other factors, such as geographical barriers or naturally low rate of dispersal, may affect gene flow among populations. Road mortality is predicted to reduce genetic diversity (based on studies in giant anteaters), but this effect is dependent on whether there is a sex-bias in road mortality within that species and the studies conducted on this topic so far are based on modelling predictions rather than empirical genetic data and better investigation of this area has been identified as a target for future research (Moore *et al.,* 2023).
Non-infectious disease	A2.7	Supplementary feeding may reduce range size (Gazzard *et al.,* 2022).
Toxin accumulation	A2.8	Rodenticides are widely present in hedgehogs (e.g., Dowding *et al.* 2009, Sophie Lund Rasmussen, ongoing work, and Garden Wildlife Health project) and it is assumed that their presence can impact hedgehog health and 'fitness'. The range of pesticides in use within UK farming and the extent of their application has increased over recent decades (Robinson and Sutherland, 2002). Pesticide prevalence is known to have negative impacts on other small mammals, such as dormice (Famira-Parcsetich *et al.,* 2022) and may be particularly problematic for hibernating species which may release large quantities of accumulated toxins from their fat during torpor.

Infectious disease	A2.9	Conspecific antagonistic encounters due to supplementary feeding are known to occur (Scott *et al.,* 2023).
Reduced carrying capacity	A2.10	There is evidence that a mixed farmland landscape supports higher densities of hedgehogs than in an arable-dominated landscape (Lee, 2021), and that agri-environment schemes can be beneficial for macro-invertebrate feeders such as hedgehogs (Hof and Bright, 2010a).
Release with complications	A2.11	
Decrease in reproductive success	A2.12	Multiple papers on the use of hedgerows/ scrub as nesting site for hedgehogs and the dramatic loss of hedgerow length and quality since World War II (e.g., Hof and Bright, 2010; Bearman-Brown *et al.,* 2020; Robinson and Sutherland, 2020; Carey *et al.,* 2008).
Inappropriate intervention	A2.13	
Euthanasia	A2.14	
Released with reduced immunocompetence	A2.15	
Released hedgehog not adapted to release site	A2.16	
Increased vehicle collisions	A2.17	It has been estimated that 167,000-335,000 hedgehogs are killed on British roads annually (Wembridge *et al.,* 2016), approximately 30% of the estimated entire national population for the species. In rural areas, road kills may have a particularly important impact as there are fewer positive factors counteracting loss with reproduction (Hubert *et al.,* 2011; Moore *et al.,* 2023). This would, at least in part, explain the divergence in hedgehog population trajectories in rural versus urban environments (Wembridge *et al.,* 2022). Motorways and main roads remain a barrier to hedgehog dispersal, though minor roads do not prevent movement (Rondinini and Doncaster, 2002).
Reluctance to intervene to save sick/injured hedgehogs	A2.18	
Increased potential for cruelty/abuse/accidents	A2.19	It is reasonable to assume that hedgehogs can be killed during site clearances for development, given that such work usually involves the removal of all vegetation by heavy machinery (e.g., https://www.dorsetecho.co.uk/news/19423761.hedgehogs-hoglets-killed-grass-verge-dorset-village-cut/). What we do not know is how many hedgehogs are killed in this way and therefore the potential impact at the population level. There is some evidence of effectiveness of mitigation measures taken during development projects (e.g. hedgehog highways Gazzard *et al.*, 2022), and non-peer reviewed work by Gloucestershire Wildlife Trust demonstrated a 39% increase in hedgehog sightings after people made highways to enable hedgehogs to get into their gardens (https://www.hedgehogstreet.org/researching-hedgehog-highways/). In addition, as urban populations of hedgehog

		are faring better than those in rural areas, the suggestion is that they can manage with such land management.
Increased predation	A2.20	Predation by badgers and foxes (and dogs) is known to occur (e.g., Young *et al.,* 2006; Rasmussen *et al.,* 2019), although predation by badgers at least may be more opportunistic than as a primary prey target (Lee, 2021). In one recent study (Scott *et al.,* 2023) the majority (c69%) of interactions between hedgehogs and badgers at supplementary feeding sites were neutral, only 31% resulting in predation or competition. Whilst the presence of hedgehogs can be inversely related to that of badgers, this relationship is insufficient to explain the large areas of rural land which support neither species (Williams *et al.,* 2018).
Entanglement/suffocation/poisoning	A2.21	Litter and other pollutants are in the environment and hedgehogs are exposed to them and could be impacted by them (e.g., https://www.itv.com/news/meridian/2018-11-09/stuck-hedgehog-highlights-uk-litter-problem).
Low hibernation survival rates	A2.22	There is some evidence of a disruption to natural processes, such as hibernation, because of climate change. In one study (Bearman-Brown *et al.,* 2020) hibernating hedgehogs awoke and moved more often than was recorded in previous studies. The hypothesis put forward for this was that fluctuating temperature could increase arousal incidences and therefore impact body condition.
Captive hedgehogs not contributing to population	A2.23	

The evidence collation exercise also produced some more general pieces of information that relate more to overarching factors or indirect threats or, in the case of light and noise pollution, did not feature in the causal flow diagram at all.

Hedgerow cover in Britain

Since 1945, hedgerow cover in Britain has declined by approximately 50% (Robinson and Sutherland, 2002). By 2007, only 48% of hedgerows in Great Britain were considered to be in good condition; this figure reduced to 12% when the quality of adjacent undisturbed land and herbaceous vegetation were included (Carey *et al.,* 2008).

Light and noise pollution

Published research on hedgehogs in Berlin demonstrate how both light and noise pollution can impact hedgehogs (and other species) (Berger *et al.,* 2020), although no such negative association with artificial light was found in another study showing that this light did not impact garden use (Gazzard *et al.,* 2022). Evidence does exist of the impacts of artificial light pollution on the behaviour of hedgehogs at supplementary feeding stations (Finch *et al.,* 2020). It is also known that light pollution influences the behaviour of moths, a prey item for hedgehogs (Berger *et al.,* 2020). In one study, moth caterpillar abundance was reduced by 47% in hedgerows and 33% in grass verges in those sites lit by street lighting, compared to the abundance in unlit sites (Boyes *et al.,* 2021). What we do not know is whether this impact goes beyond the local scale to affect the species at a population level.

***Supplementary feeding: practice and impact*s**

Supplementary feeding is known to occur. In one study (Yarnell *pers. comm.*) 20% of the inhabitants of a village participating in a citizen science project have reported this practice. Hedgehog food is publicly available for purchase. It is assumed that this practice is helpful for hedgehogs (supplementary feeding is recommended by Hedgehog Street and the BHPS) and that such feeding results in higher local concentrations of hedgehog in certain areas. What remains unknown is the population-level consequences of this practice and the extent to which benefits outweigh potential costs. Potential negative impacts include physiological ones linked to nutrient consumption, agnostic encounter risks and elevated disease transmission.

Identified knowledge gaps

The evidence collation exercise above illustrates some key knowledge gaps regarding threats to hedgehogs in Britain. While there is a good body of evidence for direct threats such as “Decrease in Food” (Table 2), there is seemingly little published data at present on many of the direct threats linked to hedgehogs being taken into vets/rehab. In particular the issues around inappropriate care and/or medication while in a vet surgery or rehab facility, the population-level impacts of euthanasia or individuals not ever being released from hedgehog rehab, and post-release complications following time in care facilities. There is also seemingly little data available on the sociological factors that may prompt or discourage people from taking hedgehogs to a care facility or moving them to a different location. A carer database would be helpful to better understand this area and this is currently in development.

Although there was discussion around the role of by-catch and killing of hedgehogs by gamekeepers as part of rural management, there is seemingly little data available to support or refute the impact of this on hedgehogs in Britain. It’s worth noting that the Game and Wildlife Conservation Trust were invited to take part in the threat analysis workshop, but were unfortunately not able to attend. Further discussion with this group around data from catch bags etc… may be helpful in establishing how often hedgehogs are killed as a result of game estate management.

Much of the genetic data currently available on hedgehog populations is relatively outdated and thus based on small numbers of markers and relatively low sample sizes. Genetic studies on hedgehogs also tend to be geographically restricted to one or two British counties, or focussed on hedgehog populations in mainland Europe rather than Britain. Two PhDs (one at Nottingham Trent University and one at the Institute of Zoology) are currently conducting new genetic analyses for hedgehogs in Britain and this data will be valuable in helping to establishing the magnitude of genetic fragmentation and isolation in British hedgehogs and what (if any) impacts this may be having on the population.

During the threat analysis workshop, there was mention of by-catch and direct mortality of hedgehogs on estates managed for game. There was also mention of an unknown around whether or not pheasants are a problem for hedgehogs via land management and competition for invertebrate food. It is hoped that the participation of the Game and Wildlife Conservation Trust at the Strategic Workshop will help to fill in some of the knowledge gaps on this topic.

Finally, although various toxins have been found accumulated in various hedgehog organs and tissues, the effect of these toxins on hedgehog health, survival, longevity, and reproductive success is not currently known. There is also a relative paucity of data on other non-infectious disease risks for hedgehogs, such as implications of supplementary feeding.

Threat analysis process and attendee list

Duration: 9:30am-5:30pm Thursday 19th January 2023
Venue: Upper Hall, Friends' Meeting House, 6 Mount Street, Manchester, M2 5NS (https://meetinghousemanchester.co.uk/conference-meeting-rooms/)

Agenda:

Time	Activity	Purpose	Lead
9:30-09:45	Arrivals		
09:45-10:00	Welcome and introductions	Who are CPSG? Rules of engagement.	Nida Al-Fulaij/ Helen Taylor
10:00-10:20	Presentation update on the status of hedgehogs in Britain and what the current threats are perceived to be	Clarify our up-to-date understanding of the status of the species (distribution, abundance etc.), population change, and data limitations. The presentation will include a summary of threats that have been identified and well-studied in the past.	Nigel Reeve
10:20-10:45	Discussion	Chance to reflect on the presentation and build on it. **Note - no 'deep dive' into knowledge gaps or perceived challenges yet!**	Helen Taylor
10:45-11:00	BREAK		
11:00-11:15	Introduction to threat analysis process	Explain the process we will be going through to develop a more detailed threat analysis for the species and to identify priority gaps in this knowledge.	Helen Taylor
11:15-12:15	Group mind map of threats	Consolidate our thinking around the range of threats for hedgehogs at the national level in both rural and urban settings. We will begin with information already collated by the Organising Team, and then check if there is further information we should add.	Helen Taylor
12:15-12:45	Clustering/categorisation exercise	Discussion of whether it is sensible to break threats into any particular categories in light of what has come up in the mind map. E.g., would two separate threat analyses for each of urban and rural be useful? Are different threats coming out for different nations? Introduce concept of logical chain before lunch.	Helen Taylor
12:45-13:15	LUNCH		
13:15-14:30	Develop causal flow diagrams of threat categories	Develop a more detailed model of how the direct and indirect threats identified in the morning session could be impacting	Helen Taylor

	(divide into groups here)	hedgehogs and how these threats are interlinked and driven (at the national level).	
14:30-15:00	Reflections on the complete causal flow diagram	Present back the work of the groups and feedback on flow diagrams from other groups to refine models and start to identify connections between models.	Helen Taylor
15:00-15:15	BREAK		
15:15-16:00	Threat patterns	Understand the potential connections between threats and perceived importance of different direct (and indirect) threats to hedgehogs.	Helen Taylor
16:00-16:30	Knowledge gaps identification	Group discussion of knowledge/ research gaps to be filled.	Helen Taylor
16:30-17:00	PESTLE analysis of the surrounding system (work on this to be continued online in the weeks following the workshop)	Identification of elements in the external environment that could impact positively or negatively on hedgehogs and on any strategy to manage the species within the next 10+ years. We will include discussions on the key knowledge gaps we need to fill, considering what might be priorities to fill before the strategic planning workshop.	Jamie Copsey
17:00-17:30	Next steps and thoughts for strategic workshop	Identification of priority actions (most likely around filling certain information gaps) to be undertaken in advance of the strategic workshop, and thoughts on key elements to include in the plan for that workshop.	Helen Taylor/ Nida A-Fulaij

Attendees
Helen Taylor - IUCN SSC Conservation Planning Specialist Group/Royal Zoological Society of Scotland
Jamie Copsey - IUCN SSC Conservation Planning Specialist Group
Nida Al-Fulaij – People's Trust for Endangered Species
Grace Johnson - People's Trust for Endangered Species
Nigel Reeve – British Hedgehog Preservation Society
Claire Howe – Natural England
Becky Clews-Roberts – Natural Resources Wales
Rob Raynor - NatureScot
Simone Bullion - Suffolk Wildlife Trust
Chris Carbone – Institute of Zoology
Lauren Moore - Nottingham Trent University
Robyn Stewart - RSPB
Elizabeth Mullineaux – British Veterinary Zoological Society
Katharina Seilern-Moy – Institute of Zoology
Jo Wilkinson – Hedgehog Friendly Campus
Orlando Methuen-Campbell – Forestry Commission England
Richard Yarnell – Nottingham Trent University
Silviu Petrovan – University of Cambridge
John Daw – RSK Biocensus
Jem Powell - JNCC

Appendices

Appendix 1: Causal flow diagram detail

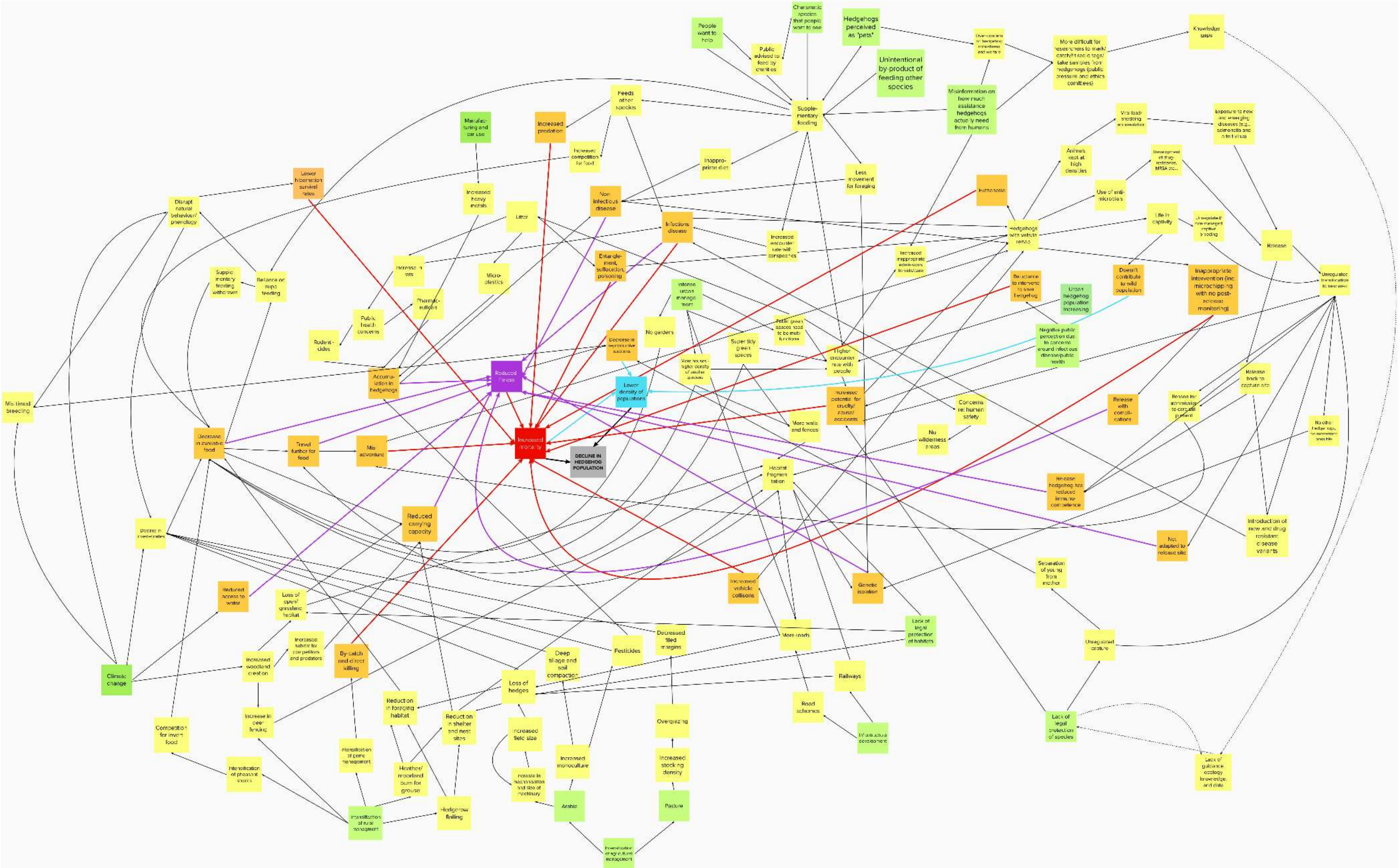

Figure A1.1: Full causal flow diagram from the hedgehog threat analysis created online in Mural based on physical, paper-based sections of the diagram at the threat analysis workshop. While the text in this diagram is not legible, it illustrates the complexity of the threat landscape for hedgehogs in Britain. All text in this diagram is represented in the individual threat breakdowns in Appendix 2. In this complete causal flow diagram, the red box is the decline in the hedgehog population (the negative outcome), the purple, blue and grey boxes are the proximal causes of decline, orange boxes are direct threats, yellow boxes are indirect threats, and green boxes are over-arching factors.

Appendix 2: Direct threat detailed breakdown diagrams

Each of the following 23 causal flow diagrams focusses on one direct threat to hedgehogs in Britain, as identified in the threat analysis workshop. In each case, the red box is the negative outcome (always = decline in hedgehogs) and the orange boxes are the proximal causes of this outcome. Yellow boxes are direct threats. The focal direct threat for each diagram is highlighted with bold text. Purple boxes are indirect threats and green boxes are over-arching factors. The colour of the linking arrows reflects the type of box the arrow is coming from.

Note that some direct threats feed into other direct threats as well as into proximal causes. In these cases, the direct threat(s) that feed into the focal direct threat are represented, but to see the indirect threats that, in turn, feed into those other, non-focal direct threats, you will need to consult the figure where those direct threats are, themselves, the focal threat. For example, in Figure A2.2, the focal direct threat is “Travel further for food”. As well as the indirect threats that link to this threat, the direct threat “Decrease in available food” is driving this focal direct threat, and this focal direct threat is itself, also driving the direct threat of “Misadventure”. To see the indirect threats linking into “Decrease in available food” and “Misadventure” the reader needs to refer to Figures A2.1 and A2.3 respectively.

Additionally, where a focal direct threat feeds into other direct threats, this is not represented on the diagram for that focal direct threat as this would add a level of complexity that we are trying to avoid in these smaller diagrams. For example, in Figure A2.11, “Release with complications” is the focal direct threat and we can see that another direct threat, “Inappropriate intervention (inc. microchipping with no post-release monitoring)” feeds into the focal direct threat and so is featured on the diagram. However, when “Inappropriate intervention (inc. microchipping with no post-release monitoring)” becomes the focal direct threat in Figure A2.13, “Release with complications” is not shown, as we are only interested in the focal direct threat feeding into the proximal causes and not into other direct or indirect threats.

There is also an additional flow diagram in this section (Figure A.2.24) that features no direct threats but illustrates a loop in the main causal flow diagram that does not link to any direct threats, but if still useful to understand for context.

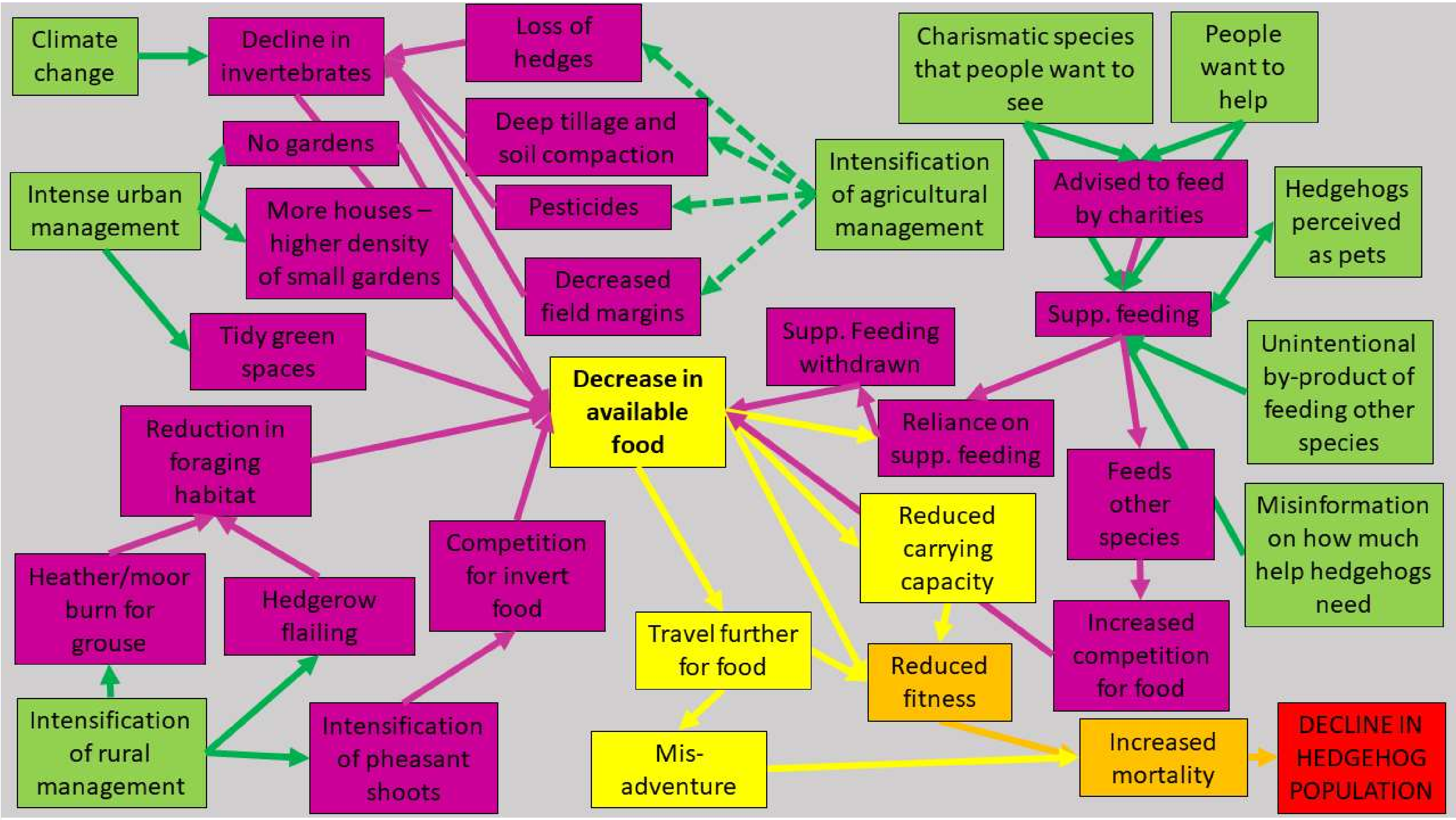

Figure A2.1: Mini causal flow diagram for the direct threat "Decrease in available food". Dotted green lines from overarching factor "Intensification of agricultural management" indicate links where additional indirect threats have been cut due to lack of space. These additional indirect threats are shown in Figure A2.1 insert below.

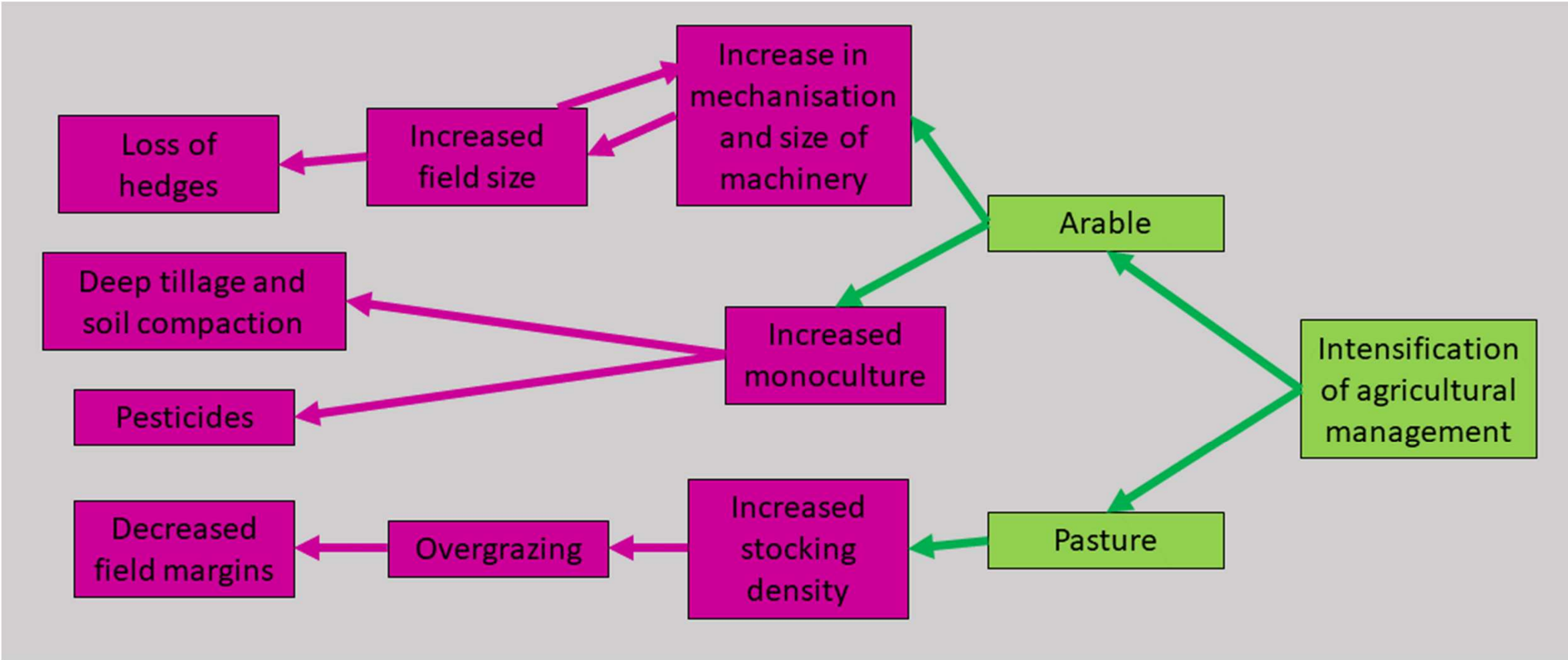

Figure A2.1 insert: Diagram illustrating the omitted indirect threats from “Intensification of agricultural management” in Figure A2.1.

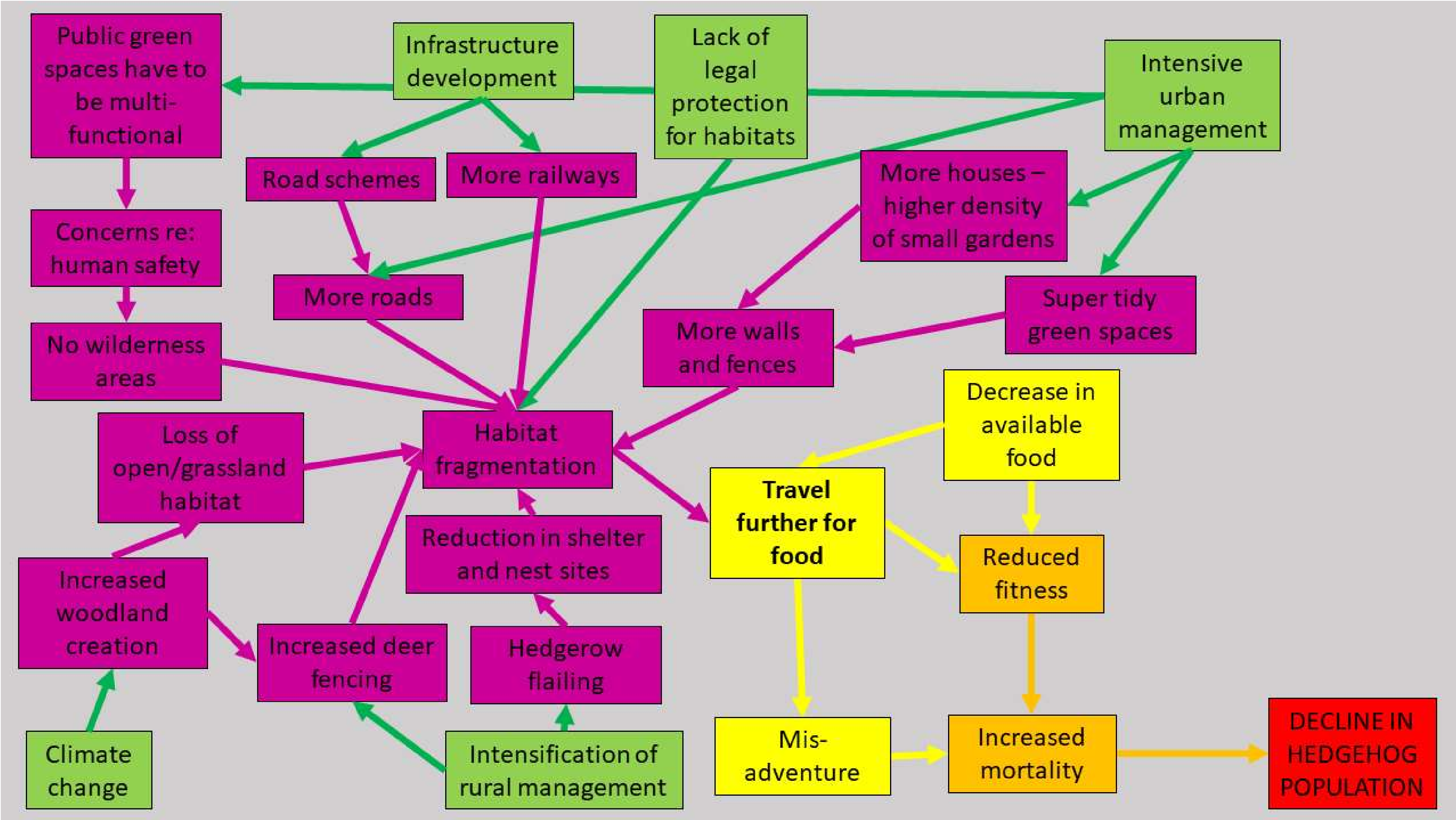

Figure A2.2: Mini causal flow diagram for the direct threat “Travel further for food”.

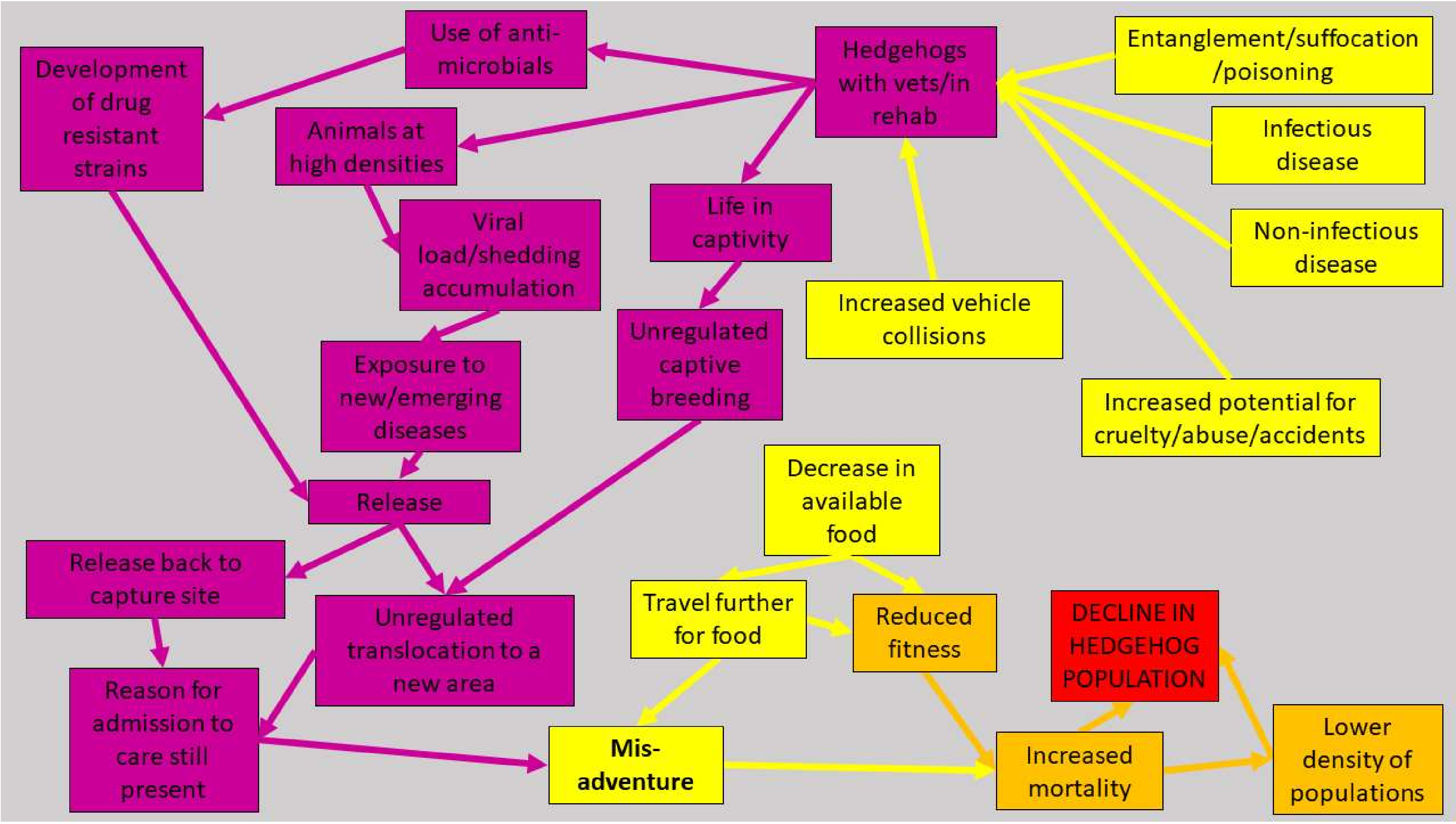

Figure A2.3: Mini causal flow diagram for the direct threat “Misadventure”.

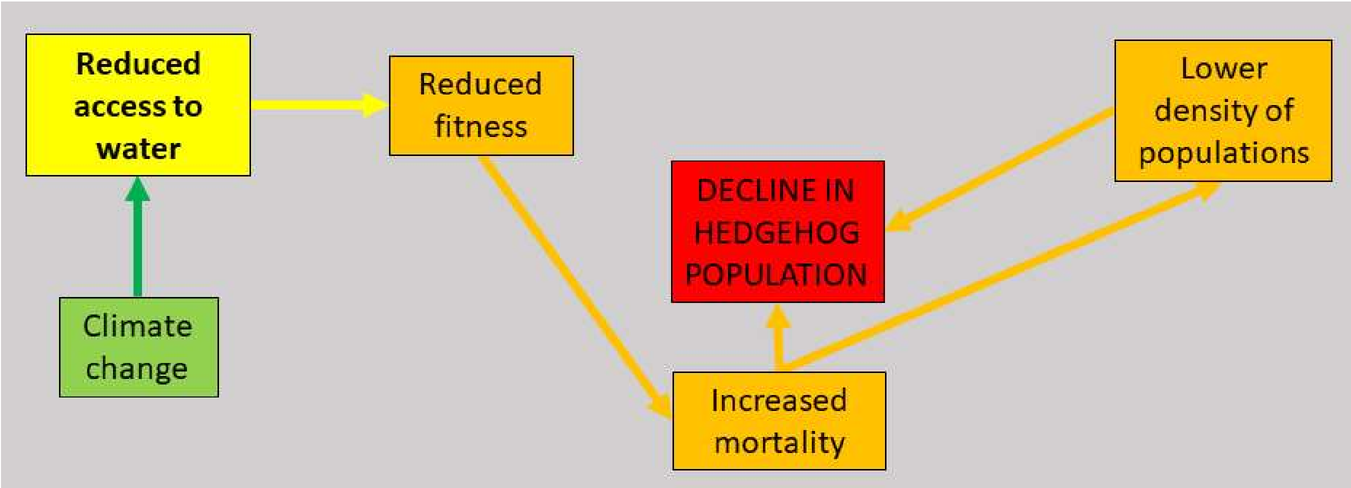

Figure A2.4: Mini causal flow diagram for the direct threat "Reduced access to water".

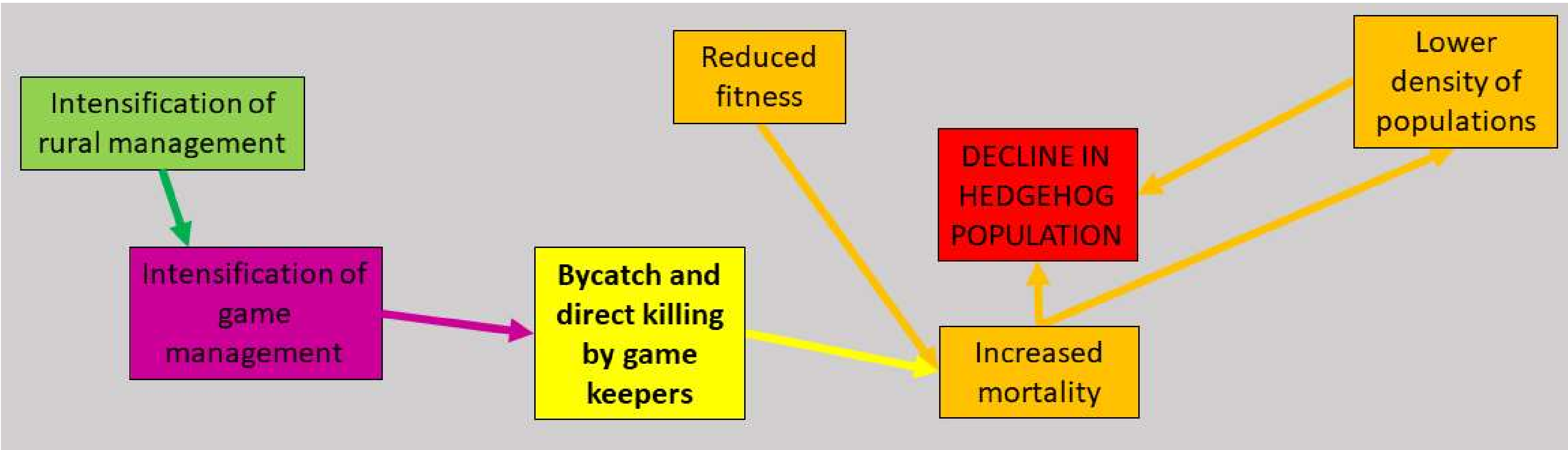

Figure A2.5: Mini causal flow diagram for the direct threat "Bycatch and direct killing by gamekeepers".

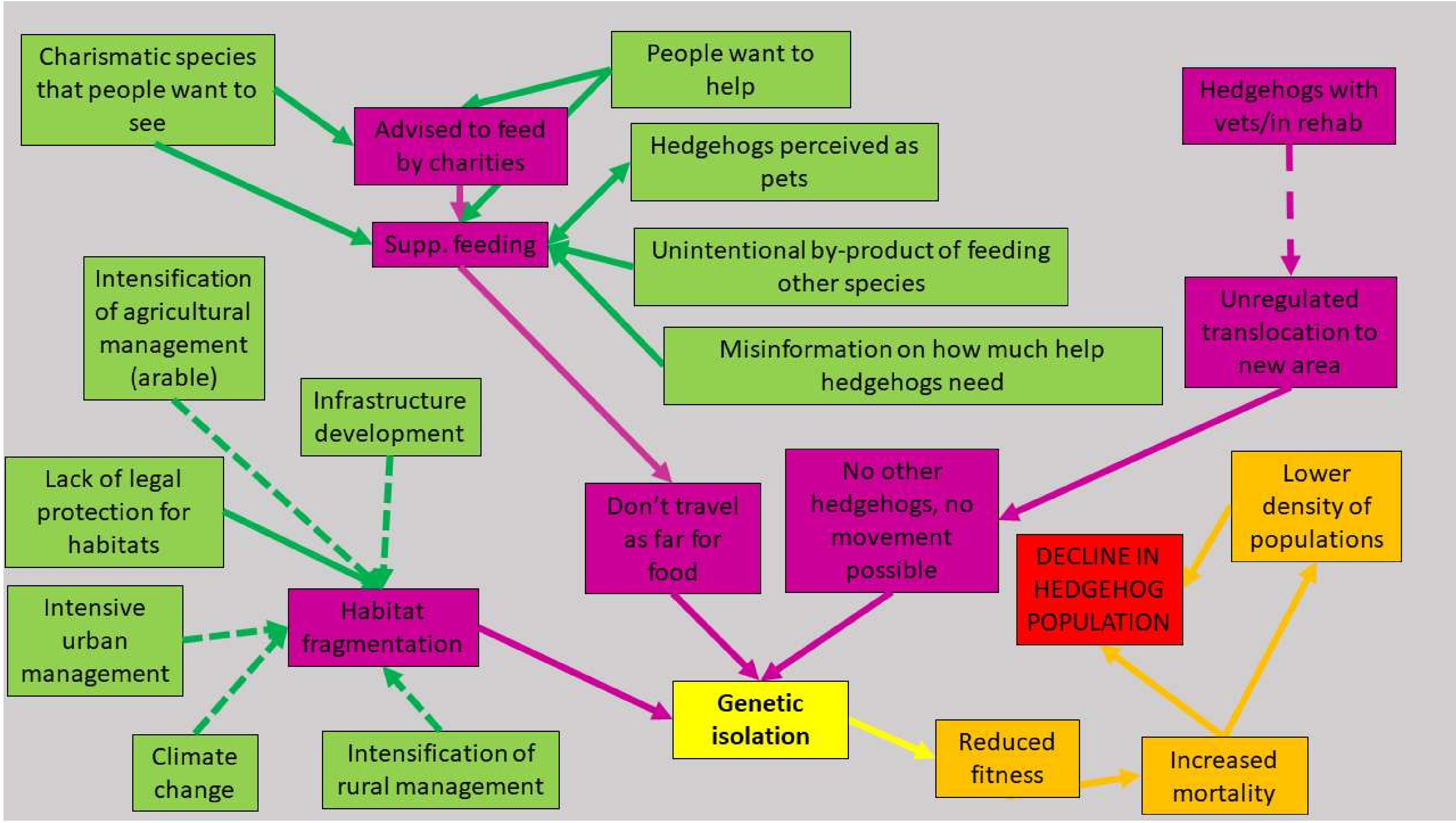

Figure A2.6: Mini causal flow diagram for the direct threat "Genetic isolation". Dotted green and purple lines indicate links where additional indirect threats have been cut due to lack of space. These additional indirect threats can be seen across various other diagrams if needed. To see missing links to "Habitat fragmentation", see Figure A2.6 insert and to see indirect threats from "Hedgehogs with vets in rehab", see Figure A2.3.

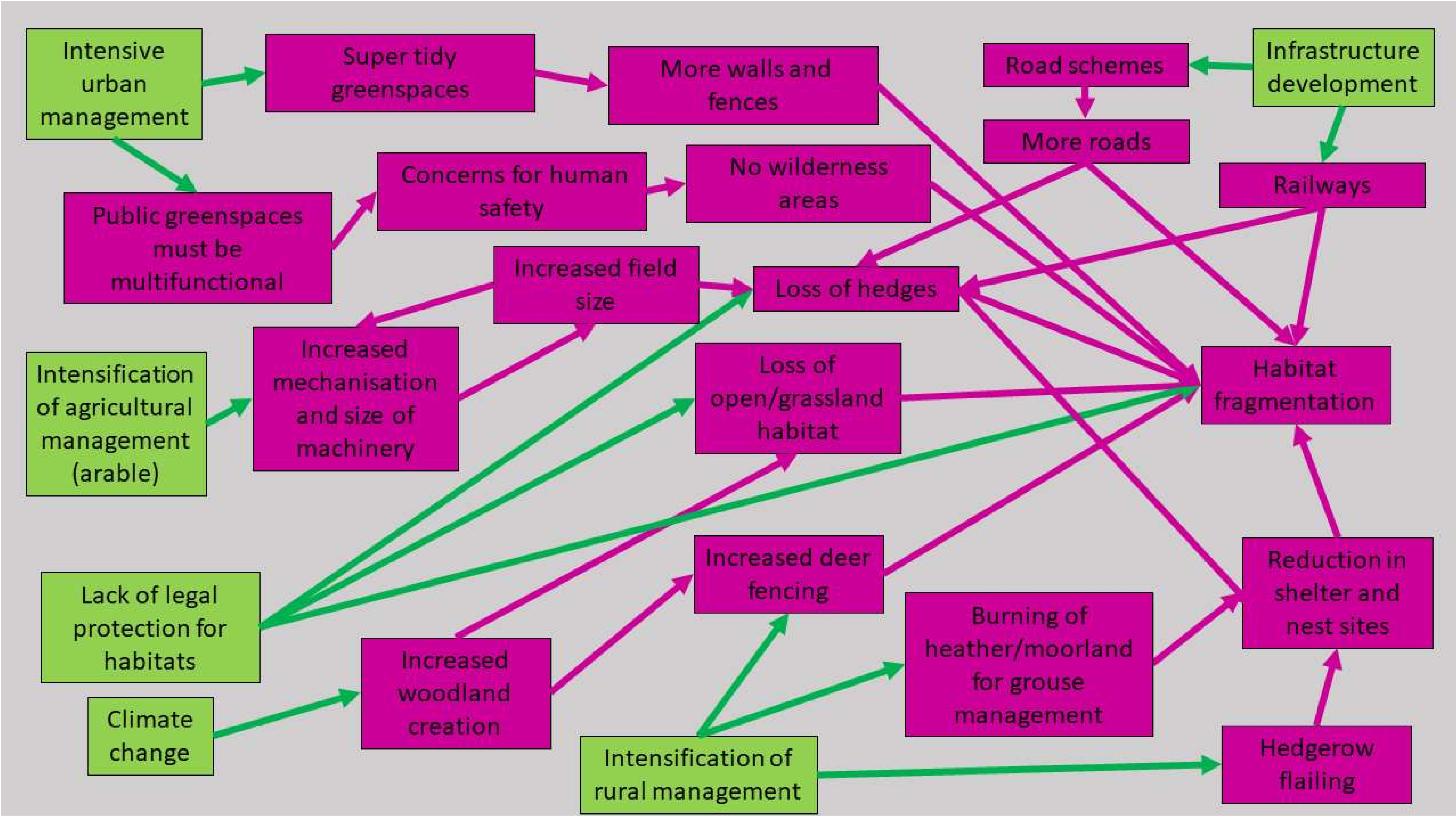

Figure A2.6 insert: Diagram illustrating the omitted links to "Habitat fragmentation" in Figure A2.6.

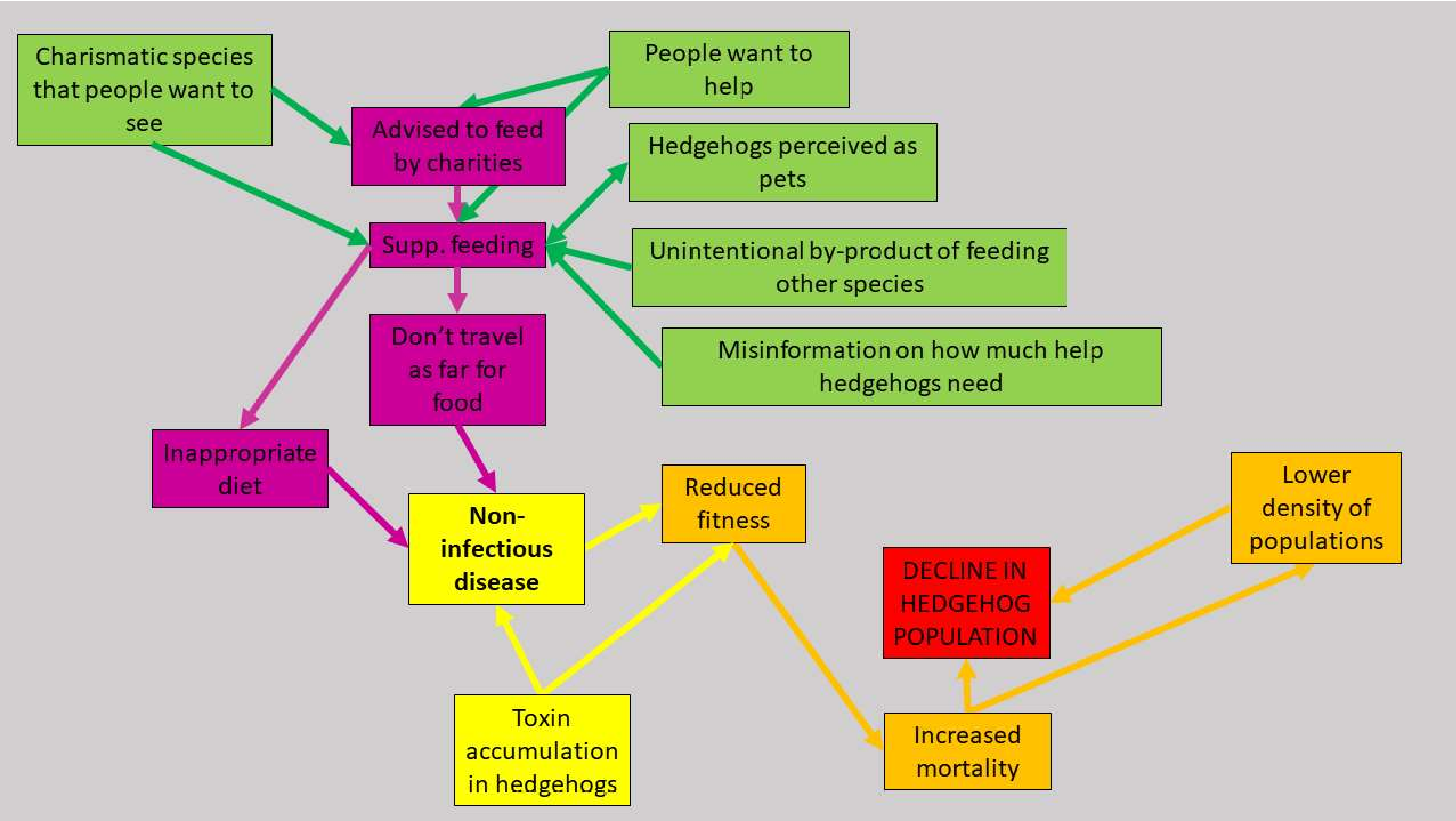

Figure A2.7: Mini causal flow diagram for the direct threat "Non-infectious disease".

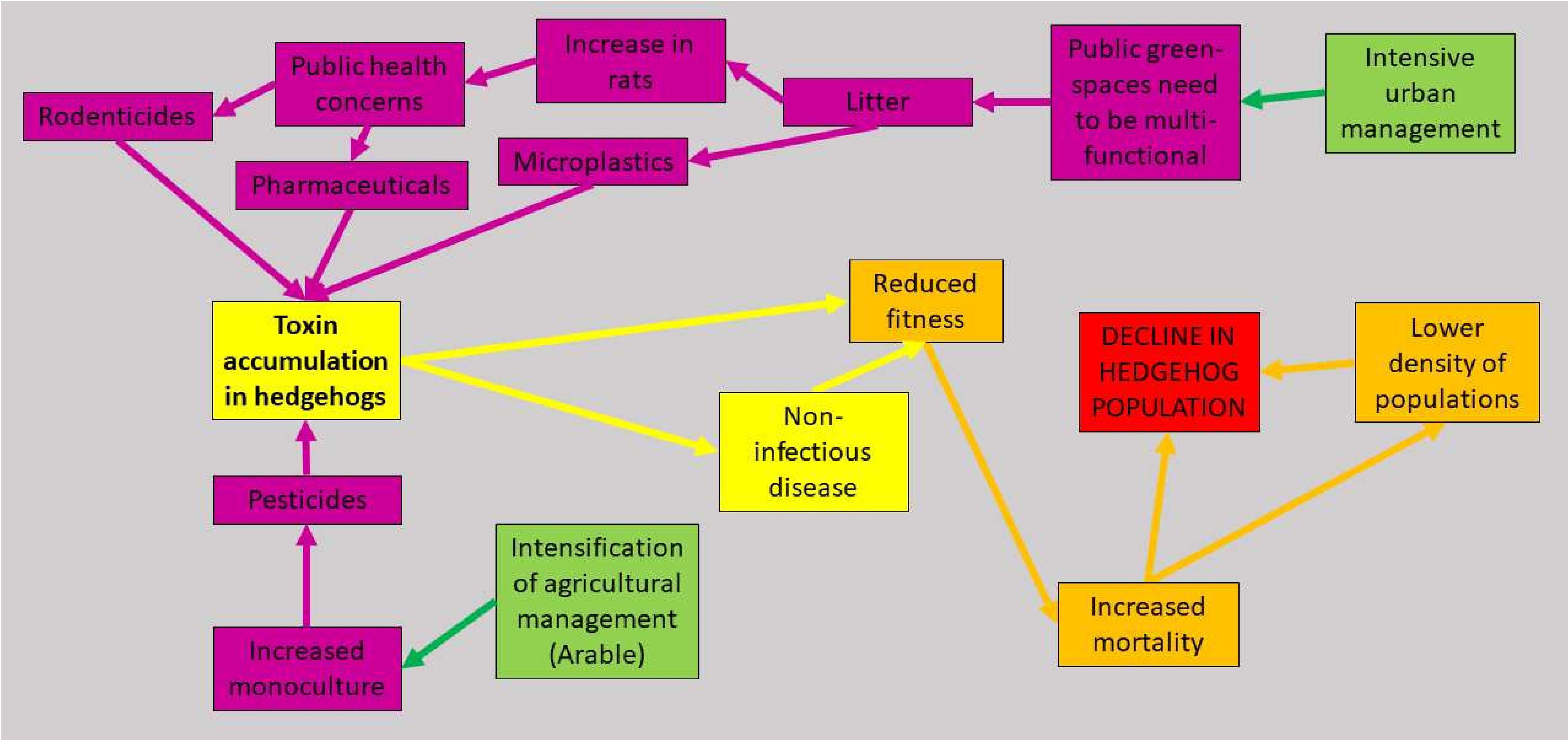

Figure A2.8: Mini causal flow diagram for the direct threat "Toxin accumulation in hedgehogs".

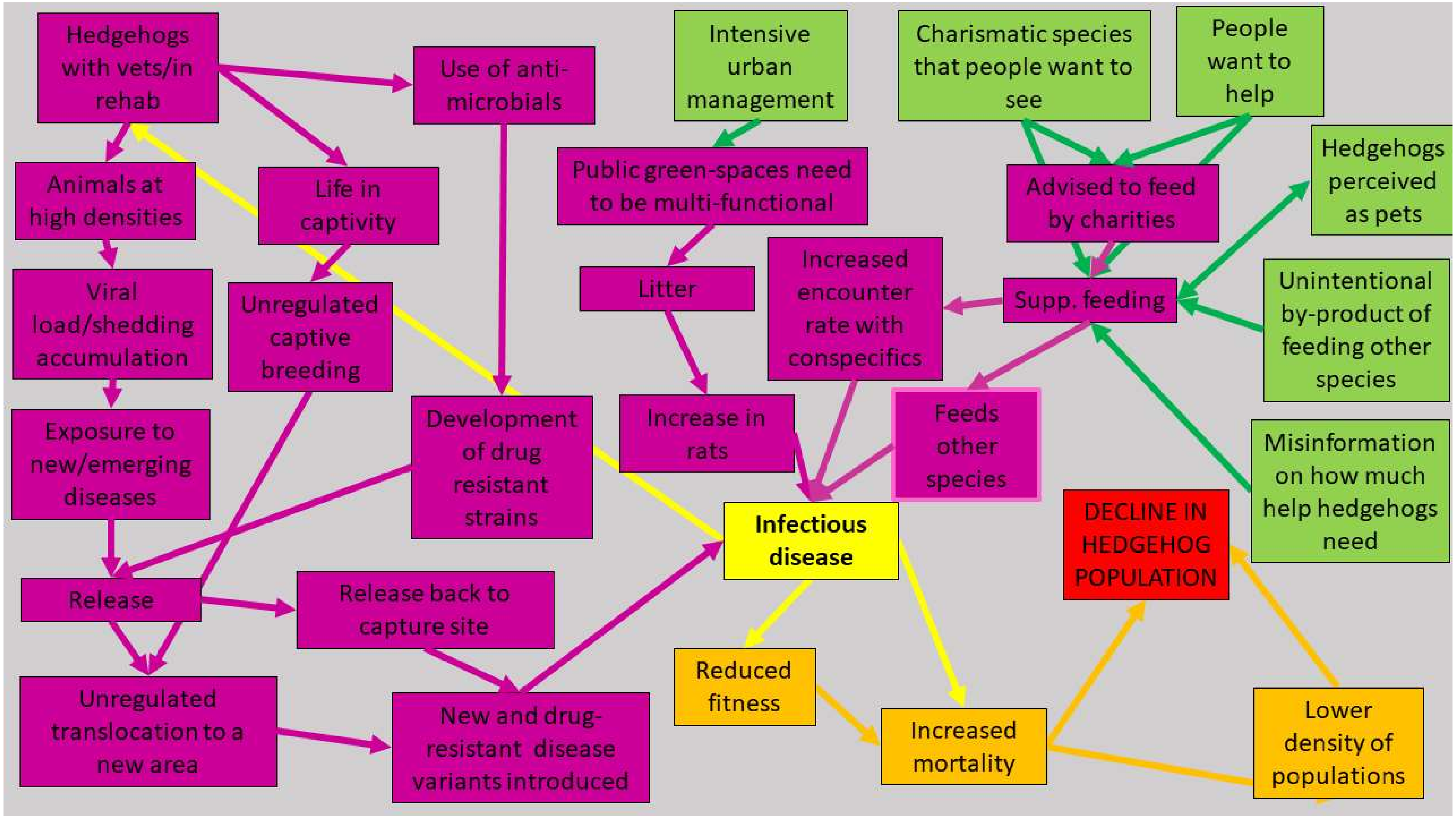

Figure A2.9: Mini causal flow diagram for the direct threat “Infectious disease”.

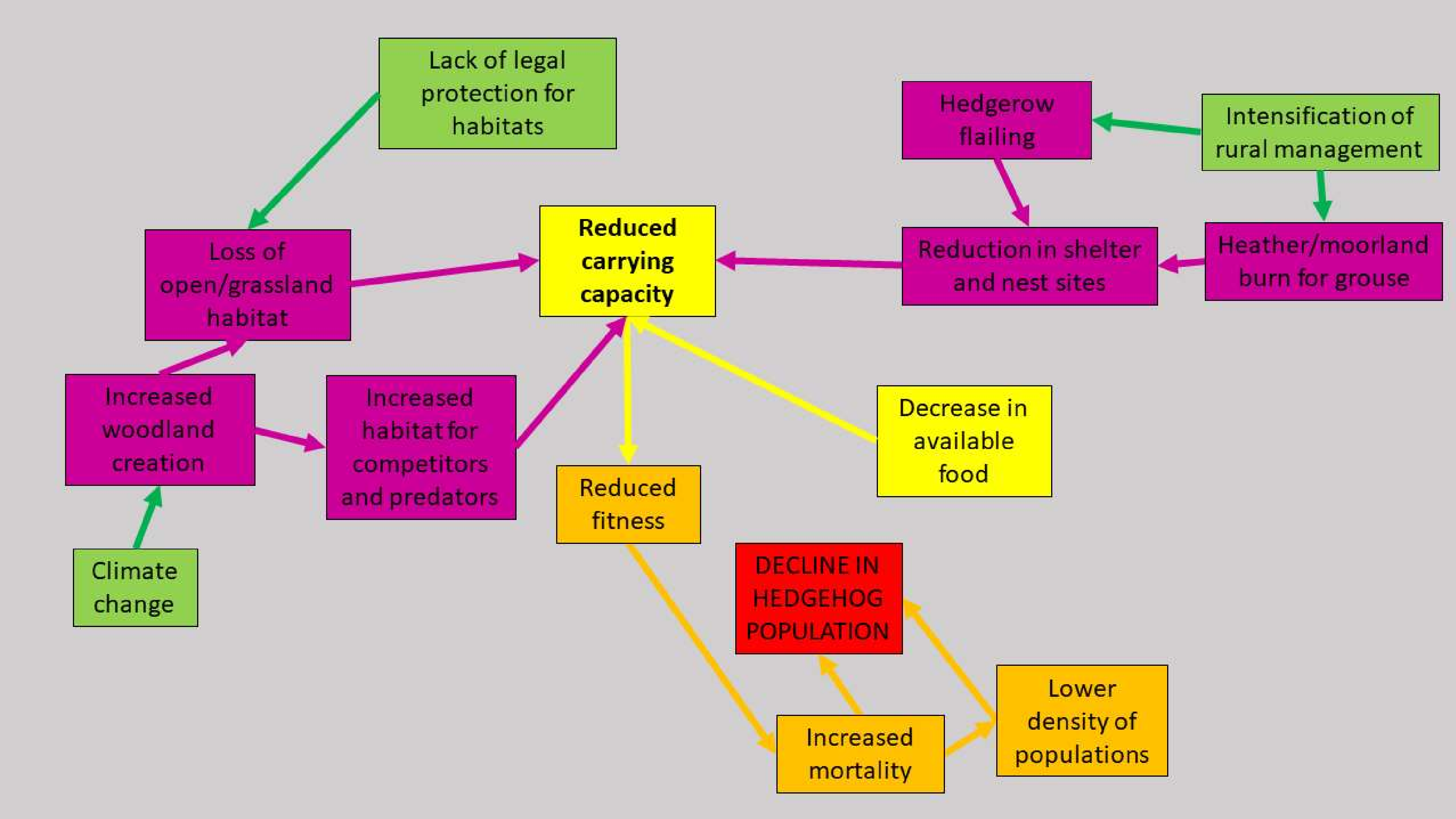

Figure A2.10: Mini causal flow diagram for the direct threat “Reduced carrying capacity”.

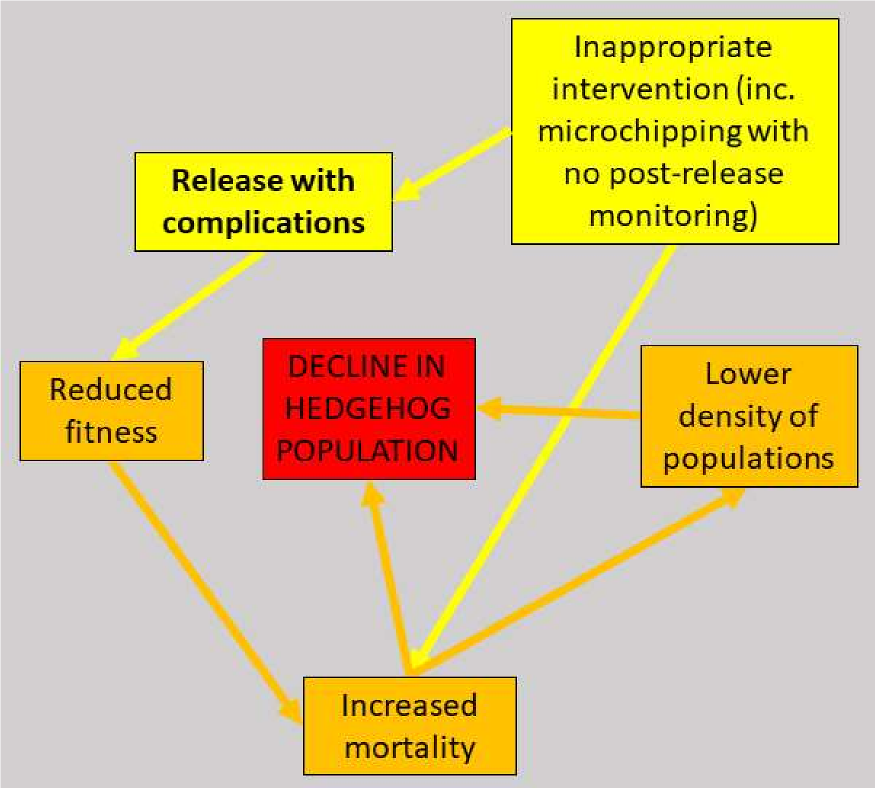

Figure A2.11: Mini causal flow diagram for the direct threat "Release with complications".

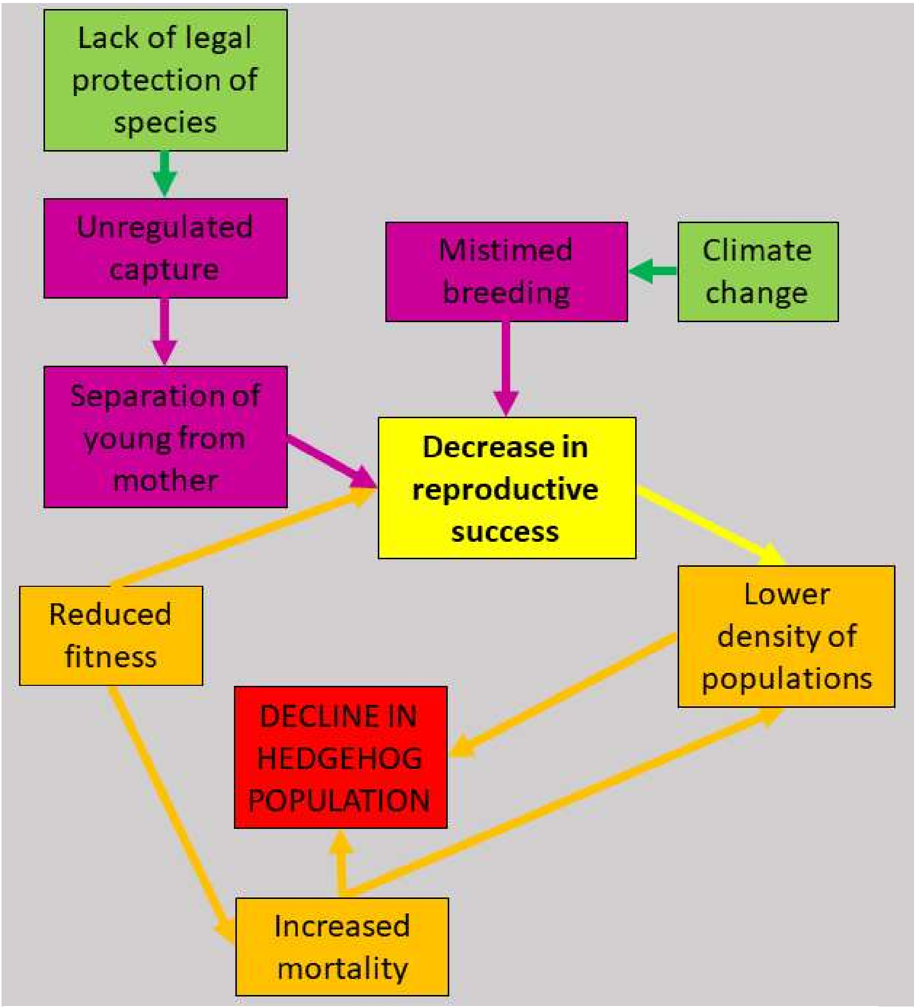

Figure A2.12: Mini causal flow diagram for the direct threat "Decrease in reproductive success".

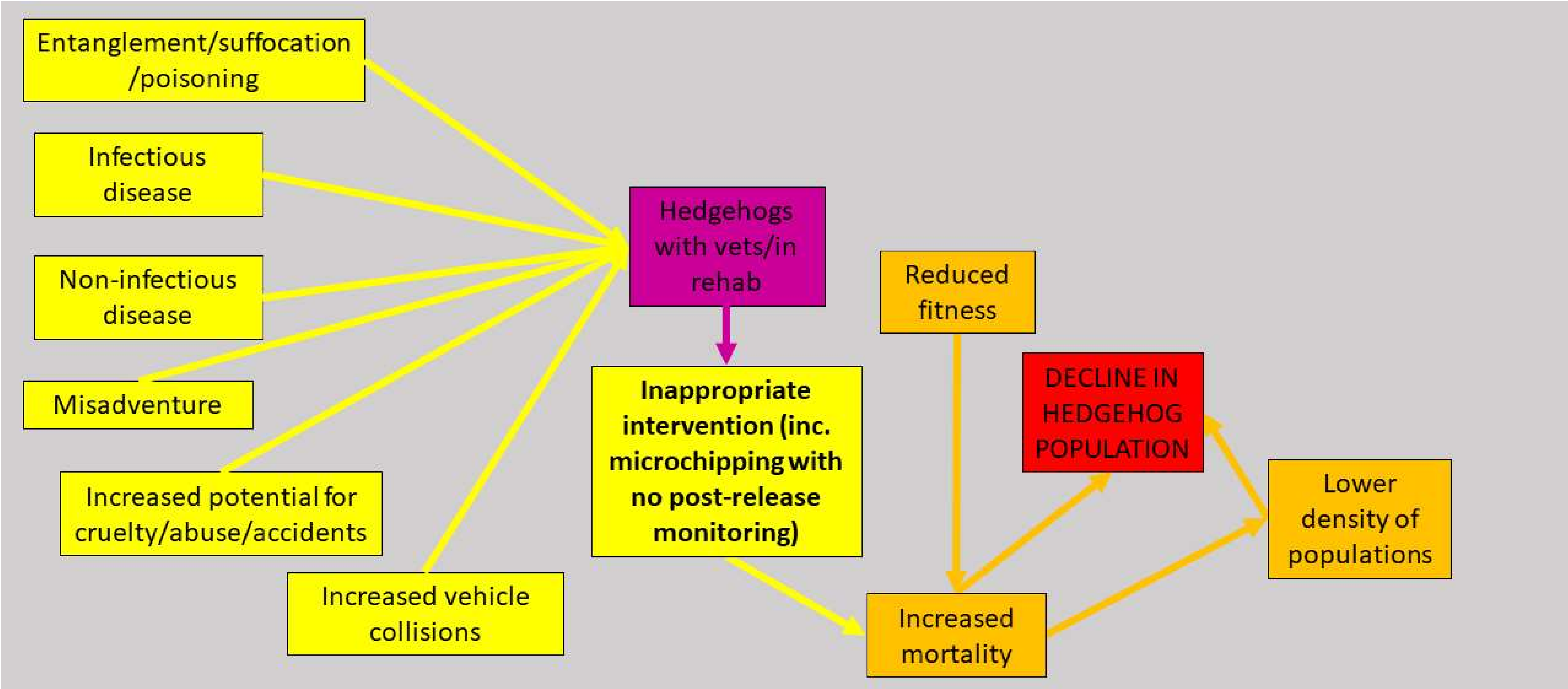

Figure A2.13: Mini causal flow diagram for the direct threat "Inappropriate intervention (inc. microchipping with no post-release monitoring)".

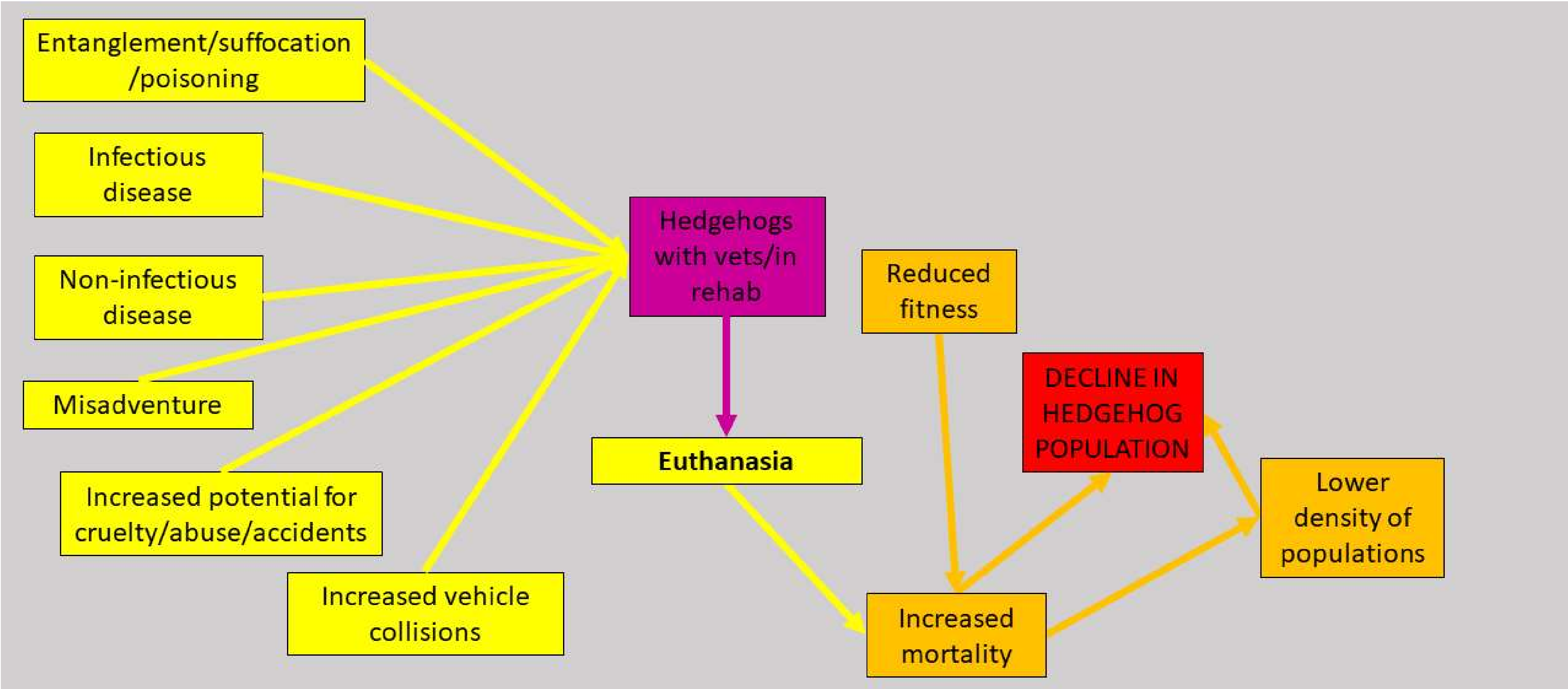

Figure A2.14: Mini causal flow diagram for the direct threat "Euthanasia".

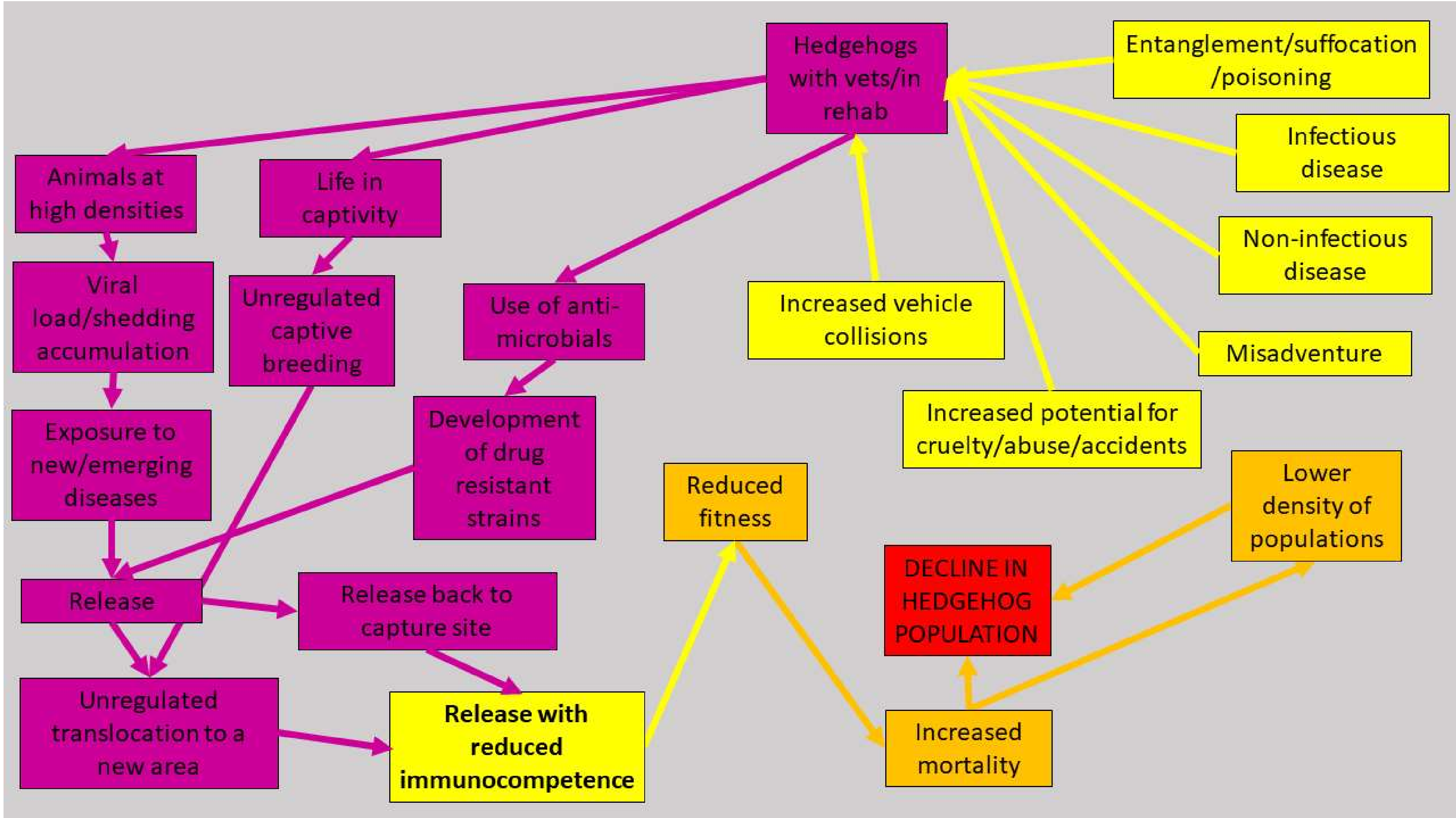

Figure A2.15: Mini causal flow diagram for the direct threat "Release with reduced immunocompetence".

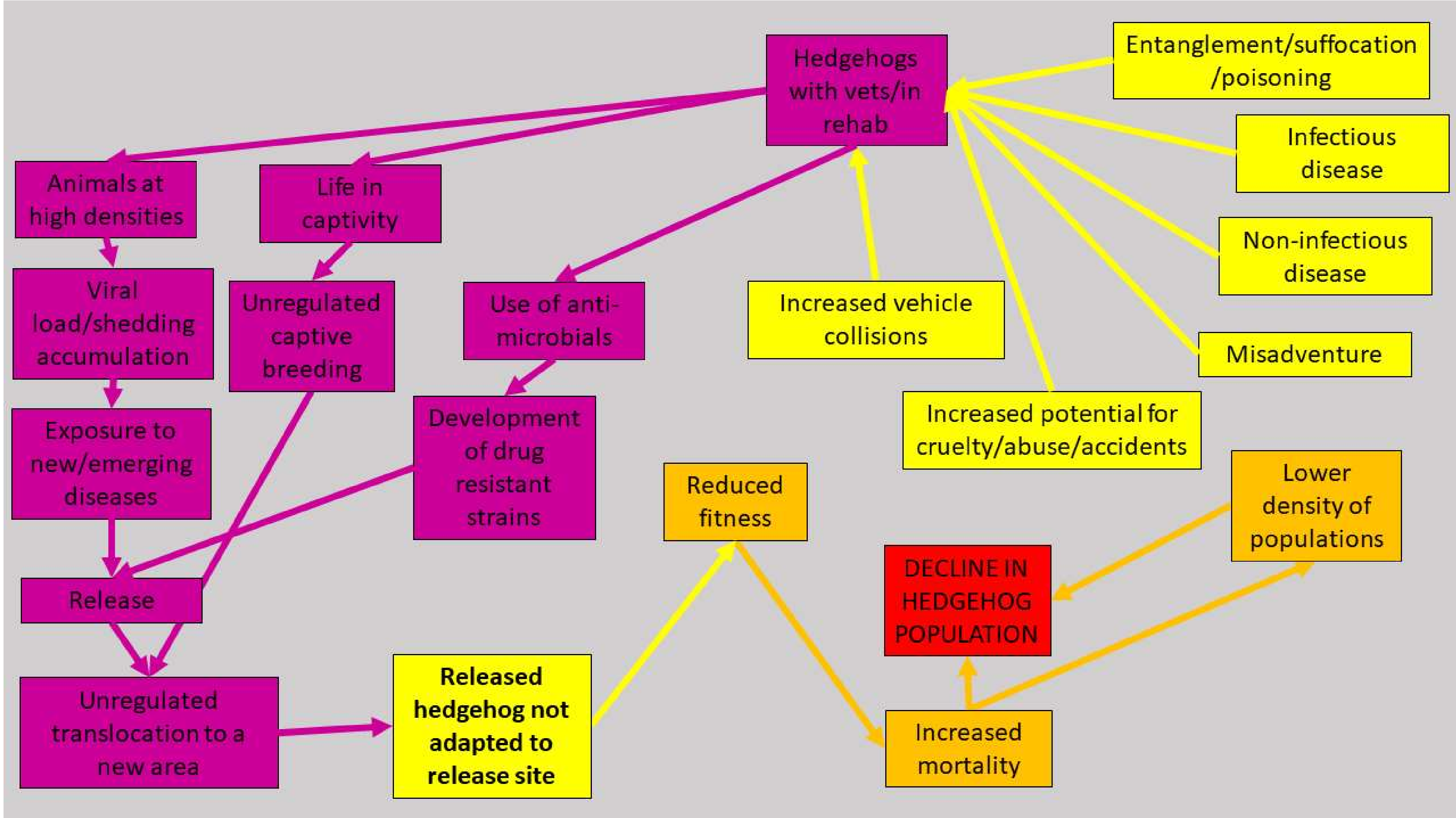

Figure A2.16: Mini causal flow diagram for the direct threat “Released hedgehog not adapted to release site”.

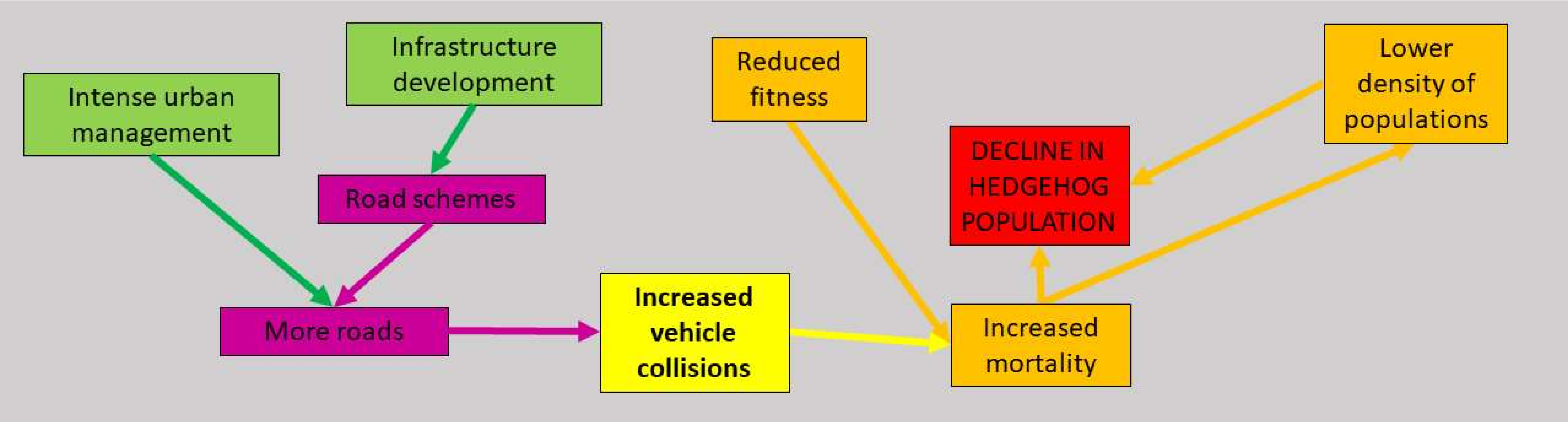

Figure A2.17: Mini causal flow diagram for the direct threat “Increased vehicle collisions”.

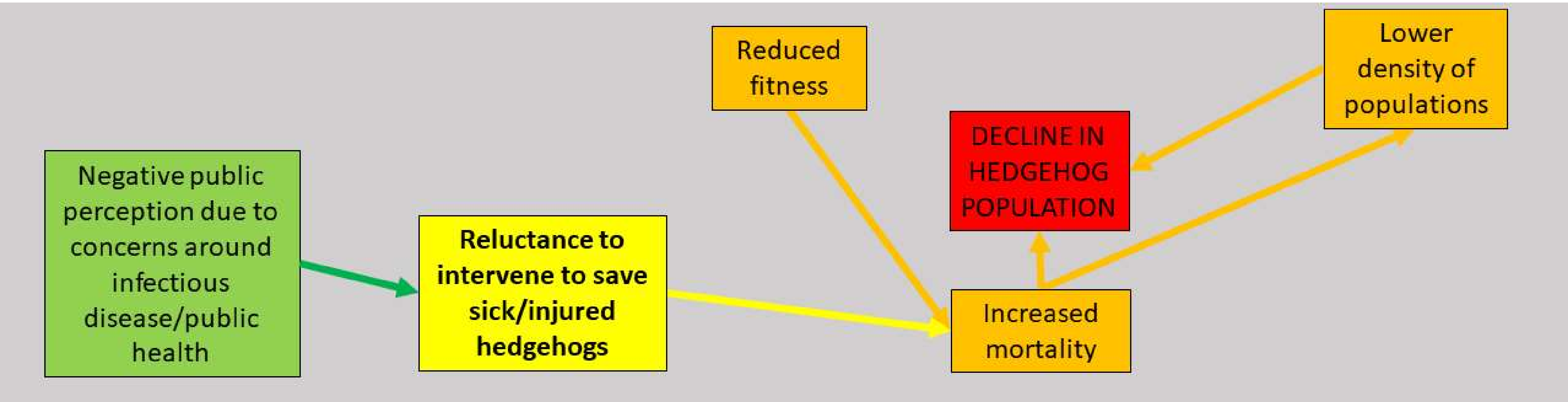

Figure A2.18: Mini causal flow diagram for the direct threat “Reluctance to intervene to save sick/injured hedgehogs”.

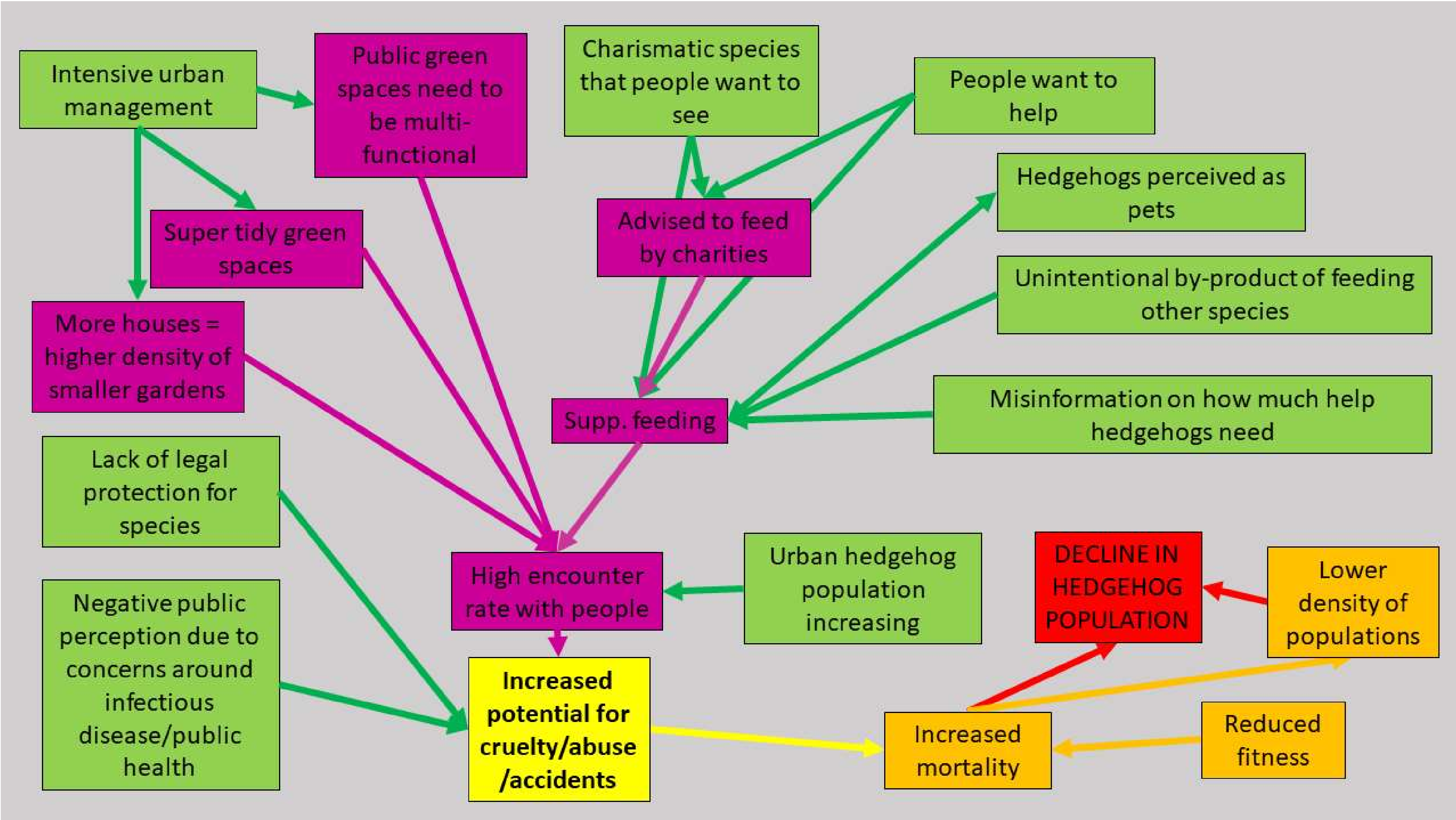

Figure A2.19: Mini causal flow diagram for the direct threat "Increased potential for cruelty/abuse/accidents".

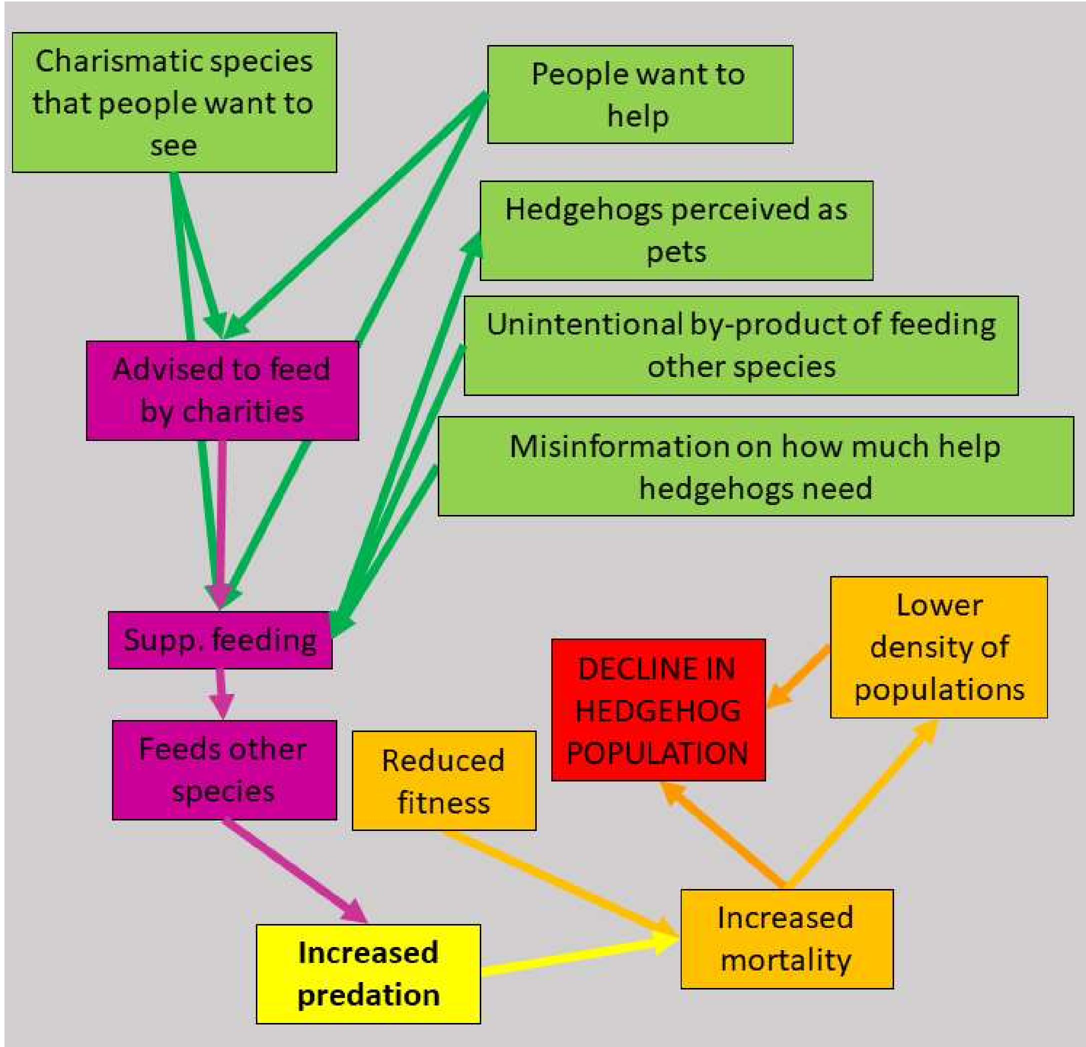

Figure A2.20: Mini causal flow diagram for the direct threat “Increased predation”.

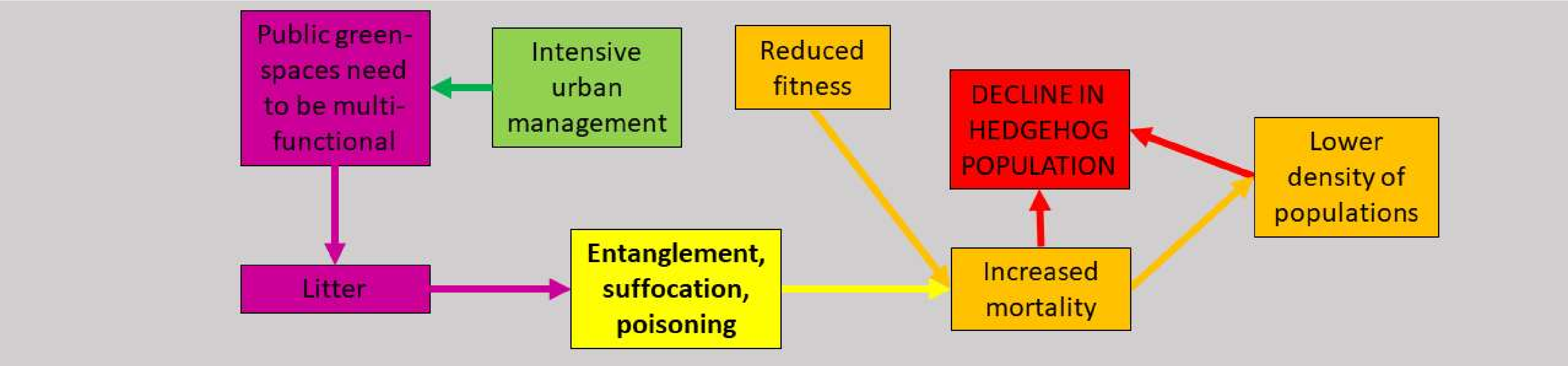

Figure A2.21: Mini causal flow diagram for the direct threat "Entanglement, suffocation, poisoning".

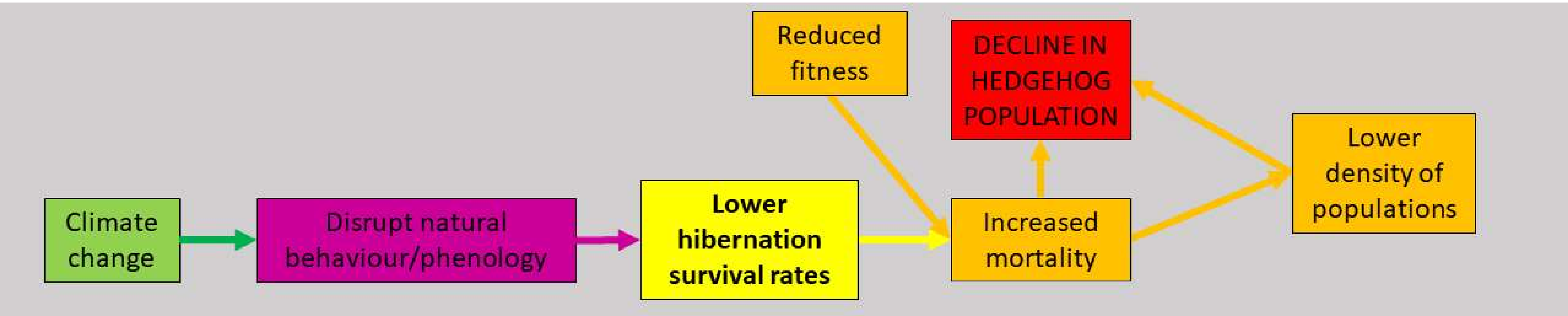

Figure A2.22: Mini causal flow diagram for the direct threat "Lower hibernation survival rates".

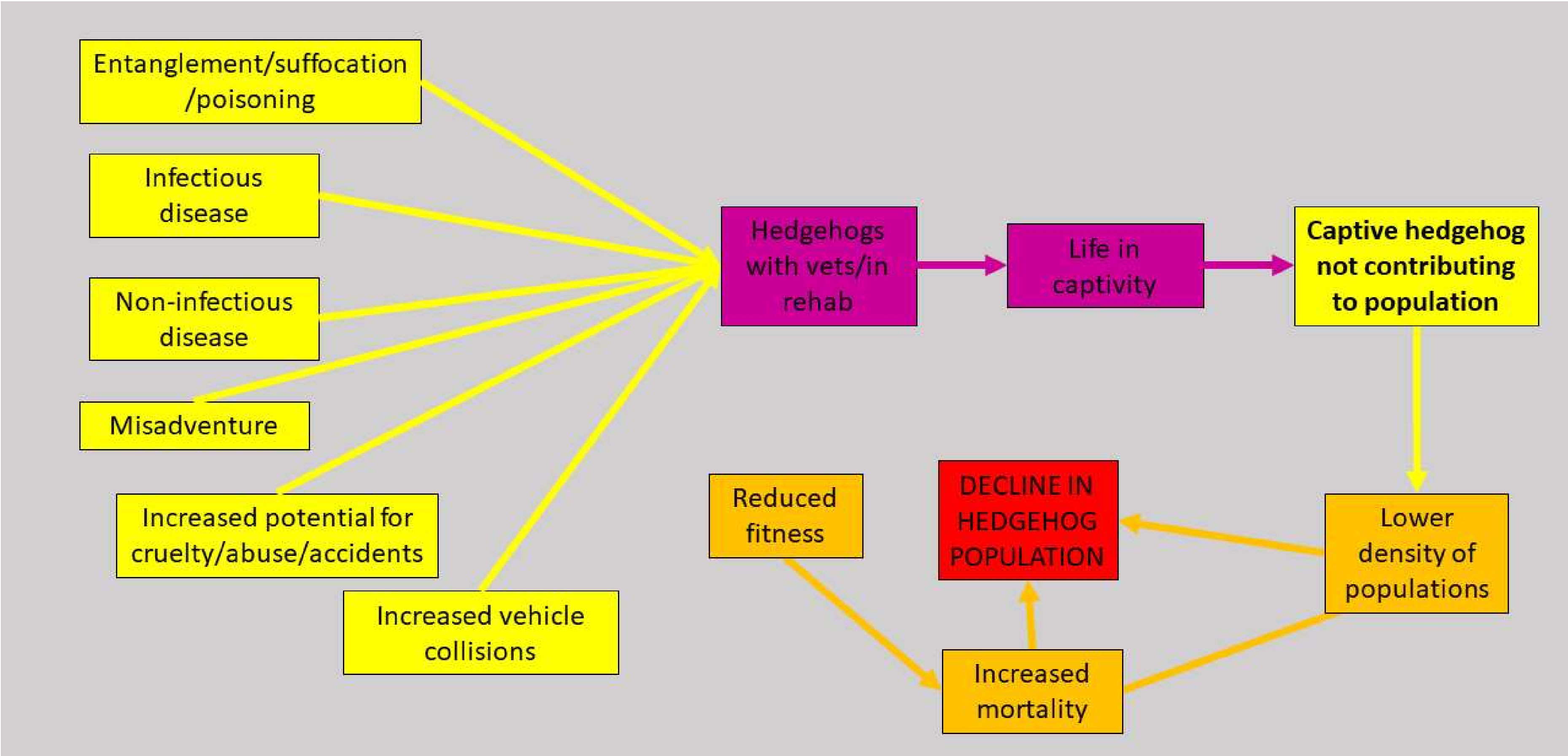

Figure A2.23: Mini causal flow diagram for the direct threat "Captive hedgehog not contributing to population".

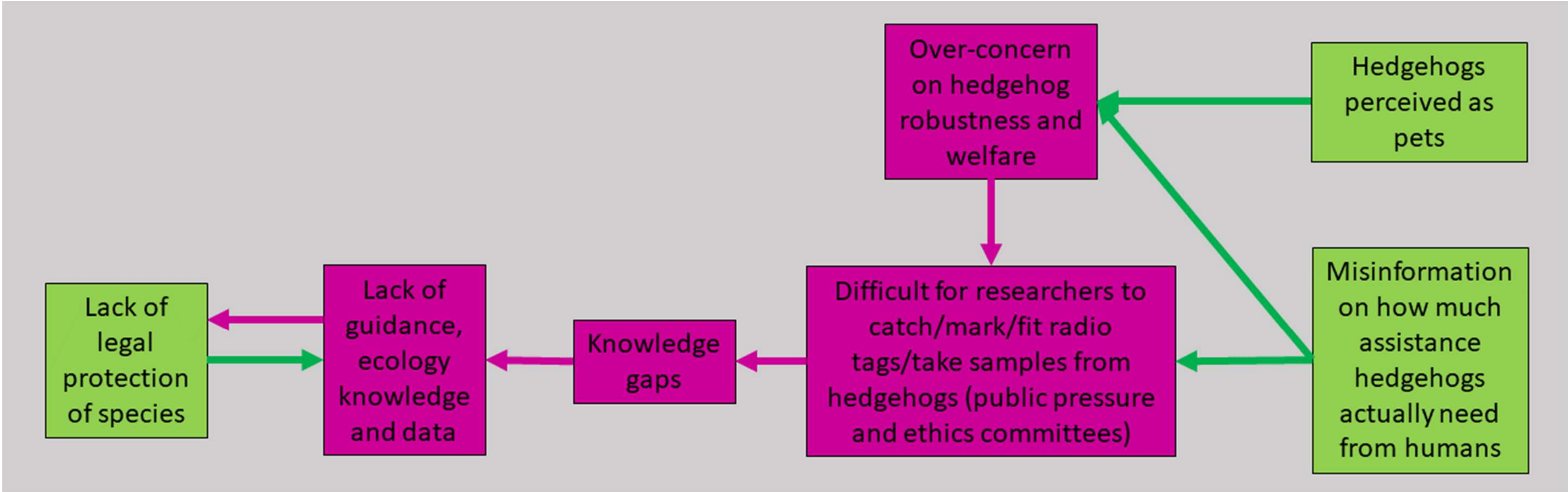

Figure A2.24: Mini causal flow diagram for a loop that featured in the main causal flow diagram, but was not linked to any direct threats closely enough to feature in any of Figures A2.1-A2.23. Presented here to ensure no information from the main causal flow diagram is lost.

Appendix 3: Known, Assumed and Unknown information linked to causal flow diagrams

The following represents a narrative summary of the exercise undertaken during the threat analysis workshop to collate what is known, thought to be known and unknown about the potential impacts of different activities on hedgehog abundance, distribution and behaviour. The topics are organised into alphabetic order and include sections related to potential research areas.

Agricultural intensification

Over recent decades, agricultural intensification across England has resulted in changes in the management, diversity and abundance of different crops, the management of grasslands has shifted from hay production to silage systems, and chemical inputs to the land have increased significantly (Chamberlain *et al.,* 2000). Overall, the amount of farmland under arable crop management has also increased (Yarnell *et al.,* 2020). There is evidence that a more mixed farmland landscape supports higher densities of hedgehogs than in an arable-dominated landscape (Lee, 2021), and that agri-environment schemes can be beneficial for macro-invertebrate feeders such as hedgehogs (Hof and Bright, 2010a). Arable fields with grassy margins help increase the availability of a particular hedgehog prey species- such as earthworms (Hof and Bright, 2010b). Recent research carried out by BTO shows a significant and long-term decline in earthworm abundance in the UK, a key prey item of hedgehogs, with associated declines in bird species which feed primarily on them such as thrush and starlings (Barnes *et al*., 2023). Another issue associated with intensification and mechanisation is field size and scale of the landscape. Hedgehogs seems to do better in small-scale agricultural landscapes (Huijser, 1999).

Potential areas for investigation: *Large-scale ecological surveys to investigate the impacts of different forms of agricultural intensification on hedgehogs would provide additional knowledge to inform our understanding of this threat at the population level.*

PTES & BHPS are planning case study working with farmers to implement positive habitat enhancements whilst monitoring hedgehogs on site, compared with control areas of the same farms left under more intensive management practices.

Climate change impacts

There is some evidence of a disruption to natural processes, such as hibernation, because of climate change. In one study (Bearman-Brown *et al.,* 2020) hibernating hedgehogs awoke and moved more often than was recorded in previous studies. The hypothesis put forward for this was that fluctuating temperature could increase arousal incidences and therefore impact body condition.

Potential areas for investigation: *The consequences of climate change on invertebrate declines would provide valuable insights into potential food limitations for hedgehogs. This could be achieved through surveying multiple sites across multiple seasons for their macro-invertebrate diversity and abundance. Studies on the impacts of warm winters (e.g. on hibernation) and drought are also needed.*

Competition and predation by other vertebrates

Predation by badgers and foxes (and dogs) is known to occur (e.g. Young *et al.,* 2006; Rasmussen *et al.,* 2019), although predation by badgers at least may be more opportunistic than as a primary prey target (Lee, 2021). In one recent study (Scott *et al.,* 2023) the majority (c69%) of interactions between hedgehogs and badgers at supplementary feeding sites were neutral, only 31% resulting in predation or competition. Competition with species such as badgers is also likely to occur (Turner *et al.,* 2021), though there is evidence of niche partitioning (in which there is little overlap in the prey items consumed by hedgehogs and badgers). The availability of field margins and associated hedgerows does seem to provide protection from predators for hedgehogs as they move through landscape (Hof *et al.,* 2012). However, whilst the presence of hedgehogs can be inversely related to that of badgers, this relationship is insufficient to explain the large areas of rural land which support neither species (Williams *et al.,* 2018).

Fragmentation of hedgehog distribution and range

Multiple radio-tracking studies in both rural and urban areas evidence the wide-ranging nature of hedgehogs (Schaus *et al.,* 2020; Pettett *et al.,* 2017, Reeve, 1982). Evidence from movement studies indicate that the population is fragmented (Moore *et al.,* 2020; Moore *et al.,* 2023), and that they seem to be avoiding roads in some instances. An assumption as to why genetic studies don't provide support is that rehabilitated hedgehogs are released more randomly. However, Becher & Griffiths (1998) found highly significant levels of genetic differentiation between closely-spaced rural populations of hedgehogs in Oxfordshire. This genetic isolation was not associated with distance between sites, suggesting that other factors, such as geographical barriers or naturally low rate of dispersal, may affect gene flow among populations.

Potential areas for investigation: *Controlled studies to test the distribution of hedgehogs before and after an intervention. The impact of deer fencing on hedgehog movement and population fragmentation is one additional area of study. Stratified surveys in particular sites and perhaps coordination with BTO and the BBS data to maximise opportunities for robust design and integration with citizen science data they collect. Studies of post-weaning and adult natural dispersal would also be useful.*

Two PhDs underway looking at genetic pattern of hedgehog populations in and around London, and UK-wide, based at IoZ and NTU.

Garden dangers

Injury through strimmers and (robotic) lawnmowers, dog attacks, drowning in swimming pools and ponds, burning in bonfires, falling down holes and outdoor cellars and outdoor 'light boxes' (designed to let light into downstairs rooms) are all known to be causes of injury and mortality to hedgehogs. Given the abundance of the species within urban settings, such threats are likely to remain, though there is no evidence that they are having population level negative impacts.

Genetic impacts

There is currently little evidence to suggest that inbreeding is leading to demographic impacts on hedgehog populations. In a study in Denmark (Rasmussen *et al.,* 2023) inbreeding did not appear to affect the lifespan of hedgehogs studied.

Road mortality is predicted to reduce genetic diversity (based on studies in giant anteaters), but this effect is dependent on whether there is a sex-bias in road mortality within that species and the studies conducted on this topic so far are based on modelling predictions rather than empirical genetic data and better investigation of this area has been identified as a target for future research (Moore *et al.,* 2023).

Potential areas for investigation: *We do not know the extent to which genetic effects- in particular, inbreeding- is having an impact on hedgehog populations within England.*

Two PhDs underway looking at genetic pattern of hedgehog populations in and around London, and UK-wide, based at IoZ and NTU.

Hedgerow decline in quality and quantity

Road verges and hedgerows act as important corridors for hedgehog movement (Moorhouse *et al.,* 2014). Since 1945, hedgerow cover in Britain has declined by approximately 50% (Robinson and Sutherland, 2002). By 2007, only 48% of hedgerows in Great Britain were considered to be in good condition; this figure reduced to 12% when the quality of adjacent undisturbed land and herbaceous vegetation were included (Carey *et al.,* 2008). Hedgerow health is a principal factor for hedgehogs. It is assumed that within poorer quality habitat there is elevated intra-guild competition and predation. In one modelling study (Moorhouse *et al.,* 2014), doubling the total length of hedgerows predicted substantially enhanced connectivity for the species. Loss of hedgerows is likely to lead to reductions in food and nest site availability for hedgehogs as well as reducing population connectivity. What we do not know are hedgehog preferences for woodland habitats.

Multiple papers on the use of hedgerows/ scrub as nesting site for hedgehogs and the dramatic loss of hedgerow length and quality since World War II (e.g., Hof and Bright, 2010; Bearman-Brown *et al.,* 2020; Robinson and Sutherland, 2020; Carey *et al.,* 2008).

Potential areas for investigation: *Studies of the extent of woodland use across multiple sites (ideally in a paired design) could help provide a robust estimation of woodland use and how it varies.*

Infrastructure development

It is reasonable to assume that hedgehogs can be killed during site clearances for development, given that such work usually involves the removal of all vegetation by heavy machinery. What we do not know is how many hedgehogs are killed in this way and therefore the potential impact at the population level. The effectiveness of mitigation measures taken during development projects (e.g. hedgehog highways) remains unknown, though evidence does exist from other species. In addition, as urban populations of hedgehog are faring better than those in rural areas, the suggestion is that they can manage with such land management.

Potential areas for investigation: *Undertake literature search and review. As per NERC Act, developers are supposed to give due regard due such impacts. It might be possible for a study to be undertaken involving a few developers providing data collected on known mortality.*

Light and noise pollution

Published research on hedgehogs in Berlin demonstrate how both light and noise pollution can impact hedgehogs (and other species) (Berger *et al.,* 2020), although no such negative association with artificial light was found in another study showing that this light did not impact garden use (Gazzard *et al.,* 2022). Evidence does exist of the impacts of artificial light pollution on the behaviour of hedgehogs at supplementary feeding stations (Finch *et al.,* 2020). It is also known that light pollution influences the behaviour of moths, a prey item for hedgehogs (Berger *et al.,* 2020). In one study, moth caterpillar abundance was reduced by 47% in hedgerows and 33% in grass verges in those sites lit by street lighting, compared to the abundance in unlit sites (Boyes *et al.,* 2021). What we do not know is whether this impact goes beyond the local scale to affect the species at a population level.

Potential areas for investigation: *Camera surveys to compare hedgehog behaviour and distribution in areas with different levels of light and/or noise pollution could be undertaken, particularly in urban settings. Such studies could be complimented with data collection on the distribution and behaviour of other invertebrate prey, such beetles.*

Litter and wider physical pollutants

Litter and other pollutants are in the environment and hedgehogs are exposed to them and could be impacted by them.

Potential areas for investigation: Studies on causes of debilitation or death of hedgehogs brought into rehabilitation centres (e.g., Garcês, 2020) could help shed light on the extent to which litter and other physical pollutants seem to be a threat to the species.

Macro-invertebrate declines

Review papers provide good evidence of the scale of macro-invertebrate declines across England (e.g., see Ball *et al.,* 2021; British Ecological Survey, 2022; Hoff and Bright, 2010b). Land management techniques (e.g., grouse moor burning) may have an impact on such populations as well as causing direct mortality to hedgehogs, as there is evidence of such mortality on other species.

Potential areas for investigation: *It would also be instructive to measure the before and after effect of letting gardens grow wild, to measure hedgehog food items and presence of hedgehogs before and after this change, which would need to be carried out on a relatively large scale i.e., more 30% of gardens in an area. A 'Wild on Purpose' campaign run in Denmark currently might provide an opportunity for such studies as well as providing an example of a possible positive intervention for hedgehogs.*

Road mortality

It has been estimated that 167, 000-335,000 hedgehogs are killed on British roads annually (Wembridge *et al.,* 2016), approximately 30% of the estimated entire national population for the species. In rural areas, road kills may have a particularly important impact as there are fewer positive factors counteracting loss with reproduction (Hubert *et al.,* 2011; Moore *et al.,* 2023). This would, at least in part, explain the divergence in hedgehog population trajectories in rural versus urban environments (Wembridge *et al.,* 2022). Motorways and main roads remain a barrier to hedgehog dispersal, though minor roads do not prevent movement (Rondinini and Doncaster, 2002).

Rodenticide and pesticide use

Rodenticides are widely present in hedgehogs (e.g., Dowding *et al.* 2009, Sophie Lund Rasmussen ongoing work, and GWH) and it is assumed that their presence can impact hedgehog health and 'fitness'. The range of pesticides in use within UK farming and the extent of their application has increased over recent decades (Robinson and Sutherland, 2002). Pesticide prevalence is known to have negative impacts on other small mammals, such as dormice (Famira-Parcsetich *et al.,* 2022) and may be particularly problematic for hibernating species which may release large quantities of accumulated toxins from their fat during torpor. It is assumed that the presence of pesticides has an impact on availability of hedgehog prey and subsequently directly on their health and indirectly through reducing food availability. The total abundance of larger moths caught in Britain decreased by 33% over 50 years (1968–2017): Southern half of Britain (39% decrease); northern half (22% decrease). Forty-one percent (175) of the species studies had experienced declines over this period (Fox *et al.,* 2021). We also know that pesticides are used widely in agriculture and in amenity areas.

Potential areas for investigation: *As with other threats what we do not know is the scale of the impact of pesticides and rodenticides on hedgehog populations, not do we know what the impact of particular pesticides on hedgehog health. Long-term studies of the impact of pesticides and rodenticides on aspects such as reproductive health could be instructive.*

Supplementary feeding: practice and impacts

Supplementary feeding is known to occur. In one study (Yarnell *pers. comm.*) 20% of the inhabitants of a village participating in a citizen science project have reported this practice. Hedgehog food is publicly available for purchase. It is assumed that this practice is helpful for hedgehogs and that such feeding results in higher local concentrations of hedgehog in certain areas. What remains unknown is the population-level consequences of this practice and the extent to which benefits outweigh potential costs. Potential negative impacts include physiological ones linked to nutrient consumption, agnostic encounter risks and elevated disease transmission. Antagonistic encounters are known to occur (Scott *et al.,* 2023). It could also be that supplementary feeding may reduce range size (Gazzard *et al.,* 2022).

Potential areas for investigation: *Controlled studies could help to determine the effects of supplementary feeding, alongside surveys to determine the extent of supplementary feeding that takes place and the quality/quantities of food provided. eDNA studies would reveal more information on diet composition and establish how frequently hedgehogs are ingesting supplementary food (and how much they depend on this to survive). Such studies would also inform our understanding of natural food item diversity, which is relevant when insects are declining drastically. Samples are available that could be used for such studies (Rasmussen pers. comm.). Veterinary studies would allow for investigations into, e.g., metabolic bone disease claims and pathogen surveys at feeding sites could inform our understanding of potential disease risks. Evaluation of commercial food product quality could reveal the extent to which these foods meet hedgehog nutritional requirements. It is important though to distinguish between studies that could inform our understanding of population-level hedgehog conservation effects from individual hedgehog welfare concerns and prioritise accordingly.*

Unregulated capture and release of hedgehogs

Potential areas for investigation: *The population level effects of unregulated capture of hedgehogs for rescue/ rehabilitation remains unknown.*

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