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PERSPECTIVE

Role of science and scientists in public environmental policy debates: The case of EU agrochemical and Nature Restoration Regulations

Guy Pe'er[1,2] | Jana Kachler[1,2,3,4] | Irina Herzon[5] | Daniel Hering[6] | Anni Arponen[7] | Laura Bosco[8] | Helge Bruelheide[2,9] | Elizabeth A. Finch[1,2,3] | Martin Friedrichs-Manthey[1,2,3] | Gregor Hagedorn[10] | Bernd Hansjürgens[11,12] | Emma Ladouceur[2,13,14,15,16] | Sebastian Lakner[17] | Camino Liquete[18] | Laura López-Hoffman[19] | Isabel Sousa Pinto[20,21] | Marine Robuchon[18] | Nuria Selva[22,23,24] | Josef Settele[2,25,26] | Clélia Sirami[27] | Nicole M. van Dam[2,3,28] | Heidi Wittmer[29] | Aletta Bonn[1,2,3]

Correspondence
Guy Pe'er
Email: guy.peer@idiv.de

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Abstract

1. Halting biodiversity loss, mitigating global warming and maintaining the long-term viability of rural and urban areas requires urgent policy action. However, environmental policies often trigger resistance and highly polarised public debates, with some actors employing pseudo-scientific claims. This raises concern about the increasing impact of misinformation on policymaking.
2. Here, we analyse the role of science and scientists in the public debate around two pieces of legislation that were proposed in 2022 by the European Commission as part of the Green Deal, namely the Nature Restoration Regulation (NRR) and the Sustainable Use Regulation (SUR) of plant protection products.
3. First, we examine key claims against these two legislative proposals and contrast them with scientific evidence. We show that these claims fail to consider ample scientific evidence that restoring nature and reducing the use of agrochemicals are essential for maintaining long-term agricultural production and enhancing food security. Critics further failed to acknowledge that the NRR and SUR may generate new employment opportunities and stimulate innovation, with high return rates and multiple beneficiaries across society, fostering a transition to sustainable production and consumption models.
4. Second, we examine how the publication of an open letter, signed by 6000 scientists, may have influenced the public debate. We contrast the role that scientific

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evidence played in the fate of the NRR, which was adopted, against the fate of the SUR, which was rejected by the European Parliament.

5. We draw lessons from these two cases that illustrate the global tension between environmental protection and economic-driven interests to spread misinformation. We argue that scientists should play an important role in making scientific evidence more accessible and available to the general public and policymakers for informed decision-making. We recommend that scientists be proactive and unbiased in providing information and data and that policymakers use scientific evidence and engage scientists in developing much needed, well informed environmental policies.

KEYWORDS

food security, land-use conflicts, misinformation, Nature Restoration Regulation, policy, science policy, sustainable agriculture, Sustainable Use Regulation

1 | INTRODUCTION

We are currently facing a combination of global crises, many of which are directly generated by anthropogenic pressures on the Earth's systems. Having already surpassed six out of nine Planetary Boundaries (Persson et al., 2022; Richardson et al., 2023; Rockström et al., 2009), urgent action is needed to find sustainable paths forward for society. Halting biodiversity loss and mitigating climate change, while maintaining long-term productivity of ecosystems used for food provision, require us to reduce the human pressures driving current crises and restore nature's capacity to recover and deliver life-support services.

Pressures to intensify the use of land and sea are still growing. Infrastructure development, land-use change and habitat degradation are continuing throughout the world, and biodiversity losses are accelerating (IPBES, 2019). While various policies and regulations globally are being negotiated and introduced, many of them are weakly designed or poorly implemented (e.g. protected areas and restoring nature; Bekessy et al., 2010; Gill et al., 2017). In other cases, existing policies are being deregulated (Gasparri et al., 2016; Ruggiero et al., 2021). Policy processes around the world are being hijacked to pursue political or economic goals, sometimes in the name of science but often using pseudo-scientific claims. For example, Samet and Burke (2020) document how the United States has deregulated pollution control by reducing the Environmental Protection Agency's research capacity and altering long-established scientific protocols. As of 2025, scientific data are being removed from numerous official US government websites, including epidemiological information, weather, climate and human population demographics (Gafney, 2025; Wikipedia, 2025).

Scientists across disciplines are concerned that public debates and policy processes at all levels are being increasingly polarised and potentially disrupted by misinformation (Yang et al., 2017). In particular, social media effectively spread misinformation as they selectively circulate content beyond their original source context (Gundersen et al., 2022)—a problem which is well known in the context of climate change (Farrell et al., 2019) and was highly evident in the case of COVID-19 (Hartley & Vu, 2020). This particularly causes problems in times when numerous new targets for national and international environmental policies are being set and ratified (e.g. Kunming-Montreal Biodiversity Framework, Convention on Biological Diversity, 2022). Measures to protect the environment are often viewed as barriers to meeting other human needs and interests, such as infrastructure development, food security or economic growth (Samet & Burke, 2020). Since failures to protect the environment have documented long-term costs for society (Ackerman & Stanton, 2008), it becomes urgent to consider how scientific evidence could be operationalised better to support decision-making processes (Cook et al., 2013; Langer et al., 2016). Public debates usually occur over relatively short periods of time, and as a result, scientists who wish to weigh in on the debate need to provide a rapid synthesis of unbiased expert opinions based on the best available evidence, while maintaining a reliable representation of complexities and uncertainties. Thus, the process of debunking misinformation may require proactive intervention in decision-making processes, without violating the role of an honest broker (Pielke, 2007).

Here, we focus on two policies recently proposed in the EU under the EU Green Deal framework, the Nature Restoration Regulation (NRR) and the Sustainable Use Regulation (SUR), as two contrasting case studies. First, we examine eight dominant arguments that were made against the NRR and SUR (Table 1; Table S1) and compare these claims with scientific evidence. We then discuss the role scientists played in the public debates around these negotiations. Finally, we reflect on the role of science and scientists in contributing to evidence-based policies, using the best available science, in highly political or contested circumstances.

2 | THE NATURE RESTORATION REGULATION (NRR) AND THE SUSTAINABLE USE REGULATION OF PLANT PROTECTION PRODUCTS (SUR)

These two legal proposals responded to the poor state of the environment in the EU. Eighty-one per cent of so-called 'Sites of Community Importance' that are presumably protected are in unfavourable or poor condition (European Environment Agency, EEA, 2020). The majority of soils in Europe (60%–70%) are classified as degraded (Veerman et al., 2020). Nearly 70% of the fish stocks are subject to overfishing and over half of these are outside of safe biological limits (Froese et al., 2018). Pesticides are detected above thresholds of concern in 83% of agricultural soils (Silva et al., 2019) and in 22% of aquatic monitoring sites (EEA, 2023), as well as in 84% of urine tests among Europeans (Ottenbros et al., 2023). These examples illustrate an overall environmental crisis, impacting our health and well-being.

The European Green Deal, as originally proposed by the European Commission (2019), attempted to respond to this crisis by providing an ambitious long-term strategy to protect and enhance the EU's natural capital. The Green Deal aims to (i) preserve and restore ecosystems and biodiversity, as reflected in the EU Biodiversity Strategy for 2030 (European Commission, 2020a); (ii) develop a fair, healthy and environmentally friendly food system, represented in the Farm to Fork Strategy (European Commission, 2020b); and (iii) reach zero pollution and a toxic-free environment (European Commission, 2021). To achieve the Green Deal objectives, the European Commission proposed several new policies, including the NRR and SUR.

The NRR (a.k.a. Nature Restoration Law) aims to establish effective restoration measures on habitats that are not in good condition (30%, 60% and 90% by 2030, 2040 and 2050, respectively) and sets targets to ensure the resilience of agri-food systems. It includes quantitative targets, timelines, wide geographical coverage and implementation details to track progress, and it addresses some key weaknesses of the present policy framework, which is based on voluntary measures (Hering et al., 2023). The NRR can therefore be considered a global landmark as a legally binding instrument to implement the Global Biodiversity Framework across borders, that is, across all EU member states.

The Sustainable Use Regulation of Plant Protection Products (a.k.a Sustainable Use Regulation or SUR; European Commission, 2022b), primarily aimed to reduce the overall use and risk from chemical pesticides by 50%, and to reduce the use of hazardous pesticides by 50% at the EU level. Other objectives of the SUR proposal were to (i) increase the application and enforcement of integrated pest management and the use of less hazardous and non-chemical alternatives to chemical pesticides, (ii) improve the availability of monitoring data on pesticides, health and environment, (iii) enhance the implementation, application and enforcement of legal provisions across Member States to improve policy effectiveness and efficiency and (iv) promote the adoption of new technologies toward these goals. The SUR would have required Member States to adopt and implement national targets toward 2030, compared to 2015–2017 as baseline years. However, these targets were not legally binding and lacked specific enforcement mechanisms.

The Green Deal has faced growing resistance, culminating in an intense political campaign against the NRR and the SUR during 2023 (Euronews, 2023). Various societal actors and policymakers argued that the NRR and SUR would impede the swift recovery of European economies from such crises as COVID-19 and the war in Ukraine. Claims were made that the NRR and SUR would have adverse effects on farmers, fishers and society at large, threatening food security, reducing jobs and competing with the transition to renewable energy (Table S1). Despite the somewhat similar claims against both, the two policies had different fates. The NRR was negotiated among Parliament Members from June to November 2023. After its final version was voted favourably in November 2023, it passed final approval by the European Council in June 2024. The SUR was rejected by the European Parliament in November 2023.

3 | KEY CLAIMS AGAINST THE NRR AND SUR AND THEIR SCIENTIFIC ANALYSIS

Here we analyse eight key claims used in the campaigns against the NRR and SUR (Table 1, concrete examples in Table S1) and compare them with scientific evidence gathered by our multidisciplinary expert group. Since this paper focuses on the policy debate during the negotiations of the legislative proposals, we refer in our NRR analysis to the original legal proposal (European Commission, 2022a).

3.1 | Land taken out of production

A key claim against the NRR and SUR was that they would result in farmland being abandoned or taken out of production, thereby leading to significant declines in agricultural production. This claim was primarily based on the fact that the NRR initially proposed that at least 10% of the EU's agricultural area should be covered with high-diversity landscape features (Article 14 in European Commission, 2022a). Taking 10% of agricultural land out of production would obviously be a valid concern for farmers (Wachter-Karpfinger & Wytrzens, 2024), especially in times of increasing demand for global food supply (European Commission, 2022c).

However, the claim that the NRR would take 10% of agricultural land out of production is erroneous. First, during the early stages of the NRR's negotiations, 'high-diversity landscape features' were redefined in a way that allowed some level of productive activities, and in its final version, the 10% target was removed. Instead, the NRR focused on improving the state of habitat types mainly in the Habitats Directive, including several grassland types that depend on the maintenance of extensive farming practices. Moreover, the

TABLE 1 Synthesis of the claims against the Nature Restoration Regulation (NRR) and Sustainable Use Regulation (SUR) and key elements of the scientific analysis. For concrete examples of the claims see Table S1.

Claim	Scientific analysis
1. NRR will take 10% land out of production	- Common Agricultural Policy already requires 3% of non-productive areas, and eco-schemes support farmers up to 7% - Land is already being abandoned in marginal regions - An adequate spatial strategy would decrease land abandonment
2. SUR will decrease yield	- Decreasing pesticide use without changing other practices may result in up to 30% yield loss - Yield is negatively impacted by soil degradation, climate change and biodiversity loss - Combining a decrease in pesticide use with agroecological practices is necessary to maintain yields
3. NRR and SUR will increase food insecurity	- Food insecurity depends on food production, accessibility, diet and waste - EU primarily exports animal products and imports feed - Reducing animal production and overconsumption, food waste and biofuel production is key to increase food security
4. NRR will decrease fishing activities	- Increasing restrictions would decrease fishing activities within Marine Protected Areas - Fisheries are mainly affected by unsustainable fishing and climate change - Restoring Marine Protected Areas would enhance yield of neighbouring fisheries
5. NRR and SUR will decrease incomes and kill jobs	- The farm to fork strategy may result in loss of jobs and farm income - Jobs are already decreasing despite Common Agricultural Policy investments - NRR and SUR can generate jobs
6. NRR and SUR will place a burden on society	- Restoring nature in protected areas would cost a total of €154 billion but the estimated benefits are at €1860, that is, a 12:1 ratio of benefits to costs - Climate change and pesticide overuse are a burden on society impacting health and extreme weather conditions
7. NRR and SUR are too risky in time of war	- The war generated an increase in food and energy prices in 2022 - Markets have rapidly stabilised in 2023 - Reducing food demand and dependencies on energy imports are more important for increasing resilience
8. NRR undermines renewable energy targets	- There are trade-offs between increasing forest biomass harvest and other uses/restoration targets - Burning biomass produces emissions and is highly contested for climate change mitigation - NRR could restore natural carbon sinks and mitigate climate change

Common Agricultural Policy (CAP) in its current funding period (2023–2027), already requires farmers to dedicate the equivalent of at least 3% of arable land to biodiversity and non-productive elements, with a possibility of receiving support via eco-schemes to reach a 7% target.

Secondly, unrelated to nature restoration efforts, some farmland areas are already gradually falling out of production in the EU. Land abandonment occurs in marginalised regions where regional socio-economic viability is undermined (Alliance Environment, 2020). This is particularly true for so-called "High Nature Value" farmlands, where CAP support is insufficient to prevent the abandonment of the least productive land (Pe'er et al., 2021; Scown et al., 2020).

Finally, the 10% claim does not affect farmers directly: the targets are set for Member States, who are flexible on how they set their own national targets, while farmers can contribute to this target on a voluntary basis. Importantly, this approach can allow for restoring agricultural habitats associated with low productivity levels, such as peatlands or areas with persistent or forecasted waterlogging and flooding (Bonn et al., 2016; Tanneberger et al., 2021).

3.2 | Yield losses

Another claim asserted that the NRR and SUR would result in yield losses and therefore a decrease in agricultural production. This was based on the assumption that the SUR would result in a full 50% reduction in pesticide use (Article 4 in European Commission, 2022b) in all crops and all EU Member States. Several studies analysed the potential impacts of such pesticide reduction on crop yields and concluded that it would indeed reduce crop yields—up to 30% in worst-case scenarios, leading to higher food prices, increased imports and reduced exports of commodities (Beckman et al., 2020). Such impacts would indeed be worrying.

However, these studies were based on a simplistic interpretation of how pesticide reduction targets could be implemented and what their impacts are likely to be (Schneider et al., 2023). Typically, pesticide reduction is not implemented in isolation but rather associated with other practices such as precision agriculture or integrated pest management. Accordingly, studies indicated that pesticide use can be reduced by more than 40% without negative effects on food productivity (Lechenet et al., 2017). This can be achieved by agroecological management practices, such as implementing diversified crop rotation (Deguine et al., 2021; Lechenet et al., 2014) or using cover crops (Wezel et al., 2014). In addition, a range of precision agriculture approaches, such as autonomous weeding robots equipped with specific spectral sensors, combined with online information systems on pest population development, can reduce the application of pesticides considerably (Anastasiou et al., 2023; Finger, 2023; Rajmis et al., 2022) and could be supported by policies (Möhring et al., 2020).

Furthermore, those studies estimating that the SUR would reduce crop yields failed to consider the positive feedback that pesticide reduction would have on yields. Biodiversity loss and associated losses of ecosystem services (Beckmann et al., 2019; IPBES, 2018) are among the main drivers of yield losses, in particular under climate change (Seppelt et al., 2020; Pörtner et al., 2021). Fifty per cent of the EU area planted with pollinator-dependent crops experiences a deficit in pollinators (Maes et al., 2020), and the potential yield losses create an economic loss equivalent to 8.1%–9.9% of the total value of plant production in the EU (FAO, 2023). Yield losses due to droughts in 2018 ranged between 15% and 25% in many German arable systems (D'Agostino, 2018), with an estimated loss valued at around €7–8 bn. (Trenczek et al., 2022); while the drought events of 2018–2020 have led to yield losses across Europe of historical dimensions (Rakovec et al., 2022). Yield losses are further affected by poor soil conditions in more than 60% of the EU area, due to reduced soil biodiversity, pollution, loss of organic matter, compaction, salinisation and soil sealing (JRC, 2023; Veerman et al., 2020). Finally, climate change increases the severity of pest infestations (Harvey et al., 2023; Lenton et al., 2019). A recent study linked the die-off of bats due to an invasive fungal pathogen in the Eastern United States with an increase of 31.3% in pesticide use to substitute losses in natural pest control by bats. This resulted in an increase of 7.9% in infant death rates in the affected counties, while crop revenue nevertheless declined by 28.9% (Frank, 2024).

The measures proposed by the two regulations could help reduce long-term risks of yield loss by increasing functional diversity, which can help alleviate the adverse effects of climate change on crop production (Dainese et al., 2019 and references therein). The values of landscape diversification are well understood and documented (Pywell et al., 2015; Pe'er et al., 2022; Petit & Landis, 2023). It can be achieved through various agroecological practices, such as maintaining semi-natural landscape features, diversifying crops, reducing field sizes, employing soil protection and restoration measures and implementing agroforestry (Reganold & Wachter, 2016).

3.3 | Food insecurity

A third claim asserted that by taking land out of production and hampering yields, the NRR and SUR would increase global food insecurity. This claim rested on the EU's central role in world markets. Some studies have estimated that the Farm to Fork and biodiversity strategies may result in increased food insecurity for an additional 30.1 million (EU-only) to 171 million (Global) people in 2030 (e.g. Baquedano et al., 2022).

However, these studies insufficiently consider that in the EU food production is not a key determinant of food security. Rather, food accessibility, food waste and high consumption of meat in industrial countries have been shown to be as important, if not more important, than global food production (FAO et al., 2021; Holt-Giménez et al., 2012; Tscharntke et al., 2012). Notably, the EU primarily exports dairy and meat products (European Commission, 2023). For instance, between 2010 and 2020, the EU produced more than its own requirements for products such as pork (117%), beef and veal (106%), poultry (111%) and milk (110%) (European Commission, 2023a). In addition, most of the grain produced in the EU is used to produce animal feed (62.4% in 2020/2021; European Commission, 2020c; Lakner, 2023) and an increasing land demand for biofuel production. This leads to increased food prices, making foods less accessible to the poorest in society (Lakner, 2023). Finally, the EU heavily depends upon imports of many products including soy (mostly for feed), palm oil, oil seeds and maize, leading to substantial use of land and resources in the global south for feed and industrial crops (European Commission, 2022d; Zinngrebe et al., 2024).

Considering the EU's huge land demand (Kastner et al., 2021), the most efficient way for the EU to contribute to both local and global food security is to reduce the production and consumption of meat and dairy products (Röös et al., 2017; Costa et al., 2022), to reduce food waste (Parfitt et al., 2010; Shepon et al., 2018) and to reduce biofuel production (Lakner et al., 2022). In Germany alone, approximately 12 million tonnes of food are wasted annually, of which 7–7.6 million tonnes are avoidable (Schmidt et al., 2019). A European legislative framework for sustainable food systems (FSFS), that was originally due for publication in autumn 2023, would have been key to achieve this transformation of food consumption patterns. The combination of the FSFS, the NRR and SUR could have therefore contributed to reaching environmental objectives without jeopardising food production, let alone food security (Röös et al., 2022).

Some misleading arguments were carried into the final formulation of the NRR. For example, Article 27 of the NRR requires the Commission to suspend its implementation in agricultural areas under emergency situations '*with severe Union-wide consequences for the availability of land required to secure sufficient agricultural production for Union food consumption*'. With only 30% of agricultural land in Europe used to food crops, we cannot foresee justifiable conditions for this to occur. If real food shortages were to occur, it would be more effective to transition the vast land tracts that are currently used for feed and fuel production to produce food crops, rather than convert the use of fallow and marginal lands—with marginal benefits but high risks.

3.4 | Fishing restrictions

A fourth claim asserted that the NRR would have a negative impact on fisheries due to limitations and changes in fishing areas. This claim was based on the fact that NRR restrictions, within strictly protected Marine Protected Areas (MPAs, Article 5), may cause a 'displacement effect' where some fisheries lose access to certain areas. Such displacements occur especially during so-called transition periods, namely in response to new management measures (Suuronen et al., 2010; Vaughan, 2017).

However, this claim failed to consider that the main risks to fisheries originate from the combination of unsustainable fisheries, climate change and pollution (Moerlein & Carothers, 2012; Pörtner & Knust, 2007). The fraction of marine fish stocks harvested at an unsustainable level globally has increased from 10% in the 1970s to almost 35% in 2017 (Stankus, 2021) and reaches 70% in some parts of Europe (Issifu et al., 2022). Large species, either directly targeted or caught as bycatch, are under exceptionally high risk of extinction (Fernandes et al., 2017). Moreover, no-take zones (i.e. the strictest protection level) cover merely 1% of the area of European MPAs, therefore having a direct effect on a marginal proportion of fisheries—and even when affected, losses can be compensated (Greenstreet et al., 2009; Suuronen et al., 2010).

In contrast, establishing MPAs, especially large and fully protected ones, has been shown to be a cost-effective means to preserve and even enhance fisheries yields (Di Lorenzo et al., 2020; Frid et al., 2023; Pendleton et al., 2018; Sala & Giakoumi, 2018). MPAs can lead to an increase in species biomass and diversity and promote the dispersal of larvae and adults of various taxa (Pendleton et al., 2018 and references therein). For example, a meta-analysis has shown that the biomass of whole fish assemblages in fully protected marine reserves is, on average, 570% greater than in unprotected areas (Sala & Giakoumi, 2018). This increase may benefit adjacent fisheries due to spillover effects from MPAs into nearby less protected or unprotected areas (Di Lorenzo et al., 2020; Edgar et al., 2014; Grorud-Colvert et al., 2021). For instance, fish abundance is 30% higher and biomass is 50% higher along the MPA borders compared to more distant regions (Di Lorenzo et al., 2020). Finally, the positive effects of MPAs are likely to persist also under climate change (Frid et al., 2023), thereby mitigating the impacts of the possibly biggest challenge that commercial fisheries will face in the future (Pendleton et al., 2018).

'High-risk' fishing practices currently take place in over 80% of the total area of MPAs in Europe and the United Kingdom (Perry et al., 2022). For example, bottom trawling, considered as especially destructive for marine flora and fauna (Steadman, 2021), harmful in terms of greenhouse gas emissions and contested in terms of socio-economic impacts (Steadman et al., 2021), has been documented in almost 60% of Atlantic and Baltic Sea MPAs (Dureuil et al., 2018). By improving the protection of a few marine areas, the NRR can therefore contribute to the restoration of key nurseries or essential fish habitats, such as seagrass and macroalgal beds and other coastal habitats, which will help the recovery of fish and shellfish, and in return benefit fisheries.

3.5 | Income and job security

Another claim was that the NRR and SUR would 'kill jobs'. Job security is indeed an important issue, since employment in agriculture and fisheries has continuously declined during the last decades. Between 2005 and 2020 alone, the number of farms in the EU declined by 37%, to 9.1 in 2020 (i.e. 5.3 million fewer than in 2005; Eurostat, 2022). Some assessments of the potential impacts of the Farm to Fork strategy did forecast losses of incomes and jobs (e.g. Barreiro et al., 2021; Beckman et al., 2020; Henning et al., 2021). These assessments, however, have been criticised due to their conceptual and practical limitations (Candel, 2022a). For instance, they ignored the socio-economic and technological adaptation capacities of farms, they ignored interactions between complementary policy instruments, and did not consider the entire value chain. Yet more importantly, they ignored the key factors affecting jobs in agriculture and fisheries, namely, structural changes (i.e. increasing centralisation) and technical progress resulting in the replacement of labour by technologies (Westhoek et al., 2014). Current agricultural policies have also disadvantaged small-scale farmers and failed to avert the ongoing rural exodus (Scown et al., 2020). Likewise, the replacement of labour by technologies has resulted in a rapid loss of jobs in the fisheries sector (Gascuel et al., 2011). Finally, the effects of climate change and land degradation further make farming a less attractive livelihood (Buchenrieder, 2007).

Highlighting job losses while ignoring both the drivers of unemployment and the potential for job creation is, at best, misleading. Efficient ways to ensure job security in the agricultural and fisheries sectors would be to improve the resilience of small- and family businesses (Björkvik et al., 2020), improve the distribution of existing subsidies, promote sustainable production and generate greater benefits by shortening value chains (e.g. direct marketing), in line with agroecological principles. By restoring ecosystems and their multiple uses, the NRR could contribute to more sustainable production while bearing the potential to create new employment, through new production models (e.g. paludiculture; Temmink et al., 2023). For instance, business models focusing on extensification tend to be more labour intensive and therefore preserve or generate employment opportunities (Vandeplas et al., 2022; Vona, 2019). Most importantly, by complementing the Nature Directives, the measures proposed by both the NRR and SUR could prevent the climate-change-induced collapse of local and regional production systems and, with them, the subsequent collapse of jobs in the coming decades. This, however, will largely depend on implementation, and particularly, the efforts made by Member States in mobilising additional funding (see also Hering et al., 2023).

3.6 | Burden on society

Another claim was that the NRR and SUR would generate new restrictions that would increase the burden on society, in a period of crises when people cannot bear additional burdens. Setting new requirements or regulations to restore nature, and developing alternatives to pesticides, does indeed require significant funding and investment. There can also be short-term local scale trade-offs between production and nature-conservation measures, generating both winners and losers (e.g. farmers, fisheries or real-estate investors affected).

In the long term and on much larger scales, however, society pays twice for the unsustainable way in which we use land- and seascapes and particularly farmlands. On the one hand, public funds are used to support farmers through the CAP, with an investment of €55 bn./year. On the other hand, unsustainable land uses contribute to climate change, biodiversity losses, soil degradation and reduction in water availability and quality, while enhancing risks, for example, from floods—while calling for compensations when damaged by these. For example, the costs to compensate farmers for yield losses due to the 2018 droughts represented €572 Mio. in Germany, Sweden and Poland alone (Bastos et al., 2020).

Another burden on ecosystems and society originates from the overuse of agrochemicals, with severe health implications. A pan-European study showed that 84% of urine samples collected from adults and children in five countries contained at least two different pesticides, with children being particularly affected (Ottenbros et al., 2023). Among the health impacts, an increased incidence in Parkinson's disease in Europe has been linked to long-term exposure to synthetic pesticides (Paul et al., 2023). The health costs due to nitrogen exposure were estimated at €75–485 bn./year, compared to a net benefit of its usage estimated at €20–80 bn./year at the EU level (Van Grinsven et al., 2013).

By contributing to climate change mitigation and minimising biodiversity loss and pesticide overuse, the measures proposed by the NRR and SUR can have economic benefits that outweigh the costs. It is estimated that restoring 10% of the areas protected under the Habitats Directive to so-called "good condition" within EU territory would cost in total circa €154 billion. The projected benefits of restoring the EU's biodiversity-rich habitats are expected to reach €1860 billion: a cost–benefit ratio of 1:12 (European Commission, 2022e). Moreover, restoring carbon-rich ecosystems provides significant economic benefits by mitigating climate change damages (Hepburn et al., 2020). For instance, the monetary value of the carbon stock of the seagrass meadows of the Baltic Sea alone was determined to be €231.9 million (Röhr et al., 2016) and the value of the carbon stock of European forests has been estimated at €1493/ha (€783–3468/ha) (Raihan et al., 2021). Beyond monetary value, biodiversity and associated ecosystem services are central to physical and mental well-being across a range of environments (Dasgupta, 2021), including the protection of lives and properties in cases of floods (Dixon et al., 2015; Mehl, 2017; Le Coent et al., 2021; Turkelboom et al., 2021), improving life quality in urban spaces (Marselle et al., 2021; Methorst et al., 2021), and supporting intrinsic and relational values (IPBES, 2022; Pascual et al., 2017). As a result, when considering the number of beneficiaries, the NRR and the SUR represent an exceptionally cost-efficient investment rather than a burden for society.

3.7 | Ukraine war

A related claim to the 'burden on society' was that one cannot place new policy burdens in a time of war, especially since the war risks increasing food insecurity and destabilising markets. The Russian war on Ukraine indeed generated a shock to food and energy prices and short-term food shortages especially outside the EU. The price for wheat increased from €275/t to circa €400/t in June 2022.

However, based on a grain deal between Russia, Ukraine and Turkey, wheat exports from Ukraine through the Black Sea were maintained in the second half of 2022, grain prices dropped to €300/t in January 2023, and the global supply situation stabilised. (Götz & Svanidze, 2023). Despite the termination of the grain initiative by Russia on 17th July 2023, the situation of the global markets continued to be stable since then. In the medium term, a tight supply situation for grain, maize and oil seeds might remain a challenge, but it has no link to biodiversity policies in the EU (Lakner, 2023). In fact, *low* prices in the Eastern EU and a reported regional *oversupply* of Ukrainian grain led the EU Commission to *restrict* deliveries of Ukrainian agricultural commodities from March 2023 onwards. In fact, the EU Commission reported a record high level of exports and imports in 2024 (European Commission, 2024a), contradicting the claim that Europe is facing a severe scarcity of commodities due to the war.

The war in Ukraine offers no argument to delay environmental legislation, certainly not on the grounds of grain scarcity. As numerous reports demonstrate, such delays are likely to lead to ever-increasing costs of action (Ackerman & Stanton, 2008; Ahmed et al., 2022; OECD, 2019; Sanderson & O'Neill, 2020; Sumaila & Cheung, 2010). Instead, crises could be wisely used as a window of opportunity to foster a more rapid transition toward sustainable socio-economic arrangements.

Finally, several reports provide more thorough analyses on policy measures that the EU can make in response to the war without compromising its sustainability ambitions (e.g. ARC2020, 2022), with some estimating that a reduction in the demand of both food production and energy for transport and infrastructure development would most effectively address the food scarcity concerns (Creutzig, 2022; Sun et al., 2022). The Green Deal, and the SUR and NRR therein, should therefore be regarded not as a burden in times of war but rather as a means to foster transition to sustainable and resilient models of production and consumption, which can reduce dependence on imported energy and agrochemicals, and at the same time ensure that agri-food systems are healthy, fair, self-sufficient and resilient (Iacobuţă et al., 2022).

3.8 | Renewable energy

Finally, claims were made that the NRR would undermine renewable energy in Europe, particularly biofuel production. It is important to acknowledge the role of forest biomass in reducing fossil fuel use

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in the short term in industries heavily reliant on them (Bioenergy Europe, 2020; Cowie et al., 2021). However, the combustion of forest biomass is not carbon neutral and the climate mitigation potential of this energy source varies widely (Cowie et al., 2021). Under some conditions, it may even emit more CO_2 per unit of energy than burning fossil fuels (Schlesinger, 2018).

There is an indisputable trade-off in maximising the harvest of wood biomass for bioenergy against restoring and maintaining forests in their natural state for biodiversity, carbon storage and other ecosystem services. This is well illustrated by the case of Finland, where chemical, forest and energy sectors outlined targets for intensified forest biomass use, well above the attainable yield from Finnish forests and over double that of the already high logging level of 2019 (Majava et al., 2022). The increased logging is projected to decrease the carbon sink, jeopardising the 2035 climate neutrality goal and posing further risks to already highly endangered biodiversity.

The targets on both the restoration of carbon-rich agricultural ecosystems and on renewable energy primarily address the mitigation of climate change. The latest independent assessment demonstrated that bioenergy may play a much smaller role in climate change mitigation than suggested by most earlier scenarios (Merfort et al., 2023). Burning residues and post-consumer wood can have the highest additionality, since this avoids the competing needs for forest biomass, but half of wood burnt in the EU is 'primary woody biomass' (about 40% of the EU's renewable energy; Camia et al., 2021). The practice of burning primary woody biomass is currently economically viable due to considerable public subsidies. It is, therefore, a highly contested tool for climate mitigation in the long term, a social burden and a high risk for biodiversity and forest ecosystem functions. Achieving the restoration targets under NRR does not preclude use of the restored and remaining forests for multiple products, including that for bioenergy, primarily from the residues and side-streams. Numerous assessments highlight that the best climate change mitigation measures are (i) protecting and restoring natural climate sinks, of which forests hold a considerable potential (Mo et al., 2023), and (ii) reducing energy demand—especially in transport, buildings and food production, which is possibly even sufficient to cut the EU dependency on imported gas and oil (Creutzig, 2022). Therefore, implementing the NRR is possible on par with restricting burning of primary woody biomass from primary forests and diverting subsidies into zero-emissions renewable energy and energy efficiency measures.

4 | SYNTHESIS OF CLAIMS AND SCIENTIFIC EVIDENCE

Notably, most claims against the NRR and SUR were linked to agriculture and food production, and based on short-term arguments such as risks of pandemics, military conflicts and financial crises. While some claims reflected valid concerns, such as potential yield declines and losses of specific job types, most were contrary to the scientific evidence (Table 1). Some claims also misinterpreted the actual nature of measures in the proposals, such as the fact that the NRR focuses primarily on improving the status of protected habitat types rather than the expansion of protected areas. Our overview of scientific evidence highlighted the importance of restoring good ecological conditions of habitats, and in particular, the need to reduce the use of agrochemicals. It suggested that benefits that could be achieved by the NRR and SUR would encompass the long-term production capacity of land and marine environments, food security, job creation, innovation and sustainable production models.

5 | THE ROLE OF SCIENTISTS IN THE PUBLIC DEBATE

5.1 | Scientists' open letter

The campaign against the NRR and SUR, based on the claims addressed above, originally placed the NRR at risk of rejection, with a 44:44 vote at the environmental committee of the EU's Parliament in June 2023. In response to the misinformation-campaign, scientists (many of whom co-authors of this paper) wrote an open letter in favour of the NRR and SUR delineating the arguments listed above. The letter was signed by 6000 scientists (Pe'er et al., 2023). Writing the open letter required understanding the two legislative proposals, identifying the main claims against these policy proposals and gathering relevant scientific evidence to address these claims by multidisciplinary experts, within a short period of time. The open letter was disseminated through scientific networks and its publication was followed by a press conference and invitations for members of Parliament to meet with scientists.

5.2 | Adoption of the NRR

The arguments of the open letter provided scientific support to NGOs and businesses, as well as government agencies and parliamentarians making their case in favour of an ambitious NRR and SUR, and voiced by major news outlets (newspapers, radio stations and social media). Overall, public support for the NRR was estimated at 80% in selected EU countries (WWF, 2024). The combined actions of NGOs, businesses, concerned policymakers and scientists moved the next Parliamentary vote toward a tight but favourable outcome for the NRR on 12 July 2023. After several rounds of amendments and further negotiations, and with a considerable delay generated by lobby pressures and re-emergence of the same claims (see #9 in Table S1), the NRR was finally approved by the European Council in June 2024, again with a tight result. During this time, numerous scientists published additional supporting letters within their countries, attended science-policy dialogues and events, and delivered supporting evidence in favour of the NRR. Overall, the intense efforts of providing scientific evidence in accessible form and direct interaction with politicians were acknowledged by various politicians and stakeholders as an important contribution to the final approval of the NRR.

5.3 | Rejection of the SUR

In 2022, following pressure from the Parliament, the European Commission generated a version of the SUR that was significantly weaker on the environmental targets than the original one. Despite such weakening, the SUR was rejected altogether on 22 November 2023, with a majority of 299:207:121 (against: in favour: abstain). In early 2024, in response to the farmers' demonstrations, Commissioner von der Leyen announced a full withdrawal of the SUR meaning that the legislative proposal will not be tabled again. This happened despite public support of the SUR signed by over 1.1 million EU citizens (see www.savebeesandfarmers.eu/eng), and an open letter signed by hundreds of European scientists, appealing the EU to approve it (Candel, 2022b). Thus, in this case, the contribution of scientists did not help.

6 | DISCUSSION

6.1 | Lessons from the different fates of the NRR and SUR

The differing outcomes of negotiations over the NRR and SUR warrant a reflection on possible reasons, as well as the role of science and scientists. In our opinion, three main differences stand out.

First, the NRR and SUR differed in terms of consensus level within the society. There is a relative consensus both in society and science for the need to restore nature. In a Eurobarometer survey among >27,000 citizens (Kantar, 2020), 94% of citizens expressed that protecting the environment is important for them; and even among farmers, the EU consultation on 'modernising and simplifying the CAP' indicated a majority of farmers supported an improvement in the environmental performance of the CAP (ECORYS, 2017). By contrast, there is less consensus with regards to the feasibility, costs and impacts of reducing agrochemical use. For instance, despite growing evidence (e.g. EEA, 2023), there is still a high level of perceived uncertainty among many citizens about the causal relationship between pesticides and human health impacts. Moreover, implementing alternatives such as Integrated Pest Management requires substantial learning and investments in research, development and extension services (Deguine et al., 2021).

Second, the NRR and SUR differ in the degree of voluntary participation. In the NRR, most of the proposed measures are optional for those involved, while in the SUR, the measures were obligatory. Moreover, arguments in favour of the SUR were mostly about long-term health benefits for consumers, whereas counterarguments focused on short-term fears regarding food insecurity. For instance, the interruption of supply chains triggered by COVID and the war in Ukraine have influenced the perceptions of food security of European consumers. Moreover, decades of reliance on pesticides have resulted in a high-risk-aversion behaviour among many producers (Chèze et al., 2020). This may explain why misinformation was much harder to address in the case of the SUR than in the NRR.

Third, the role of industry, and sectors that stood most to lose, differed. If approved, the SUR Regulation would have had a direct impact on agrochemical producers, potentially leading toward reduced dependence of farmers on such chemicals. Goulson (2020) highlights the efforts of the agrochemical industry to block initiatives toward the reduction of pesticide use, and Deguine et al. (2021) demonstrate how the agrochemical industry has been shaping the distorted adoption of Integrated Pest Management by lobbying, marketing, and manipulation. As producers of agrochemicals are among the most active and powerful lobbies, pressure on politicians to reject the SUR was likely much higher (Deguine et al., 2021 and references therein). By contrast, the potential impacts of the NRR spread among many sectors, possibly allowing for processes of deliberation and compromise.

6.2 | Global relevance

The debates around the NRR and SUR legislation and environmental policy are not unique to Europe. Globally, land- and sea-use conflicts are worsening and environmental resources are dwindling; while in many parts of the world, environmental legislation and policies are facing increased resistance, pressures for deregulation or complete cancellation. Likewise, the use of misinformation in environmental debates becomes increasingly common globally. Examples are the use of make-believe controversies and misleading arguments to aid the dismantlement of environmental conservation policies in Brazil (Forti et al., 2023; Rajão et al., 2022), inaccurate claims on the impacts of agrochemical products by those working within the industry, demonstrated for example in a case study in Guatemala (Murray & Taylor, 2000), or misleading the public about the causative link between fossil fuel use and climate warming by members of the fossil fuel industry, as, for example, by ExxonMobil in the United States (Supran et al., 2023). The Dublin Declaration, a pro-livestock statement on the societal role of livestock without acknowledging health risks and environmental impacts, provides another recent example of a flawed scientific advocacy that shows how selective evidence and unwarranted polarisation can compromise the integrity of academic engagement (Herzon, 2024; Krattenmacher et al., 2024). It is increasingly difficult to address the misuse of evidence due to the use of sophisticated strategies, including pseudo-scientific claims (e.g. Adams et al., 2023; Farrell et al., 2019; Swire-Thompson & Lazer, 2022) and selective use of evidence by researchers linked to the industry (Krattenmacher et al., 2024). However, as demonstrated by Schmid and Betsch (2019), effective rebuttal strategies of misinformation do work. The case of the NRR provides further evidence on the crucial role of scientists in public debates: by debunking misinformation, highlighting beneficiaries versus losers and addressing questions of broad societal interests by the scientific community, scientists contributed to the passing of an important regulation that was close to rejection based on misinformation.

6.3 | Toward a constructive dialogue

Societal and political debates are inherent elements of societal transformations and will become increasingly important in upcoming urgent, cross-sectoral transitions such as those needed toward more environmentally sustainable land and water use practices. However, the robust implementation of environmental and social justice principles in the policy process needs to be reliant on using empirical evidence to deliver on policy targets and impacts.

Inevitably, any new regulation will either directly or indirectly favour some stakeholders over others: some could take advantage of these regulations, while others may need support in adapting to them. Disparities in the consequences on stakeholders may trigger conflicts, as is known to happen with other sustainability policies, such as transition to a low- or zero-carbon economy (Radtke & Scherhaufer, 2022). Accordingly, it is important to identify wide-ranging and long-term benefits to as many stakeholders as possible and achieve broad support from society, businesses and policymakers. A constructive dialogue can be guided by highlighting win-wins, or so-called co-benefits (see, e.g., Karlsson et al., 2020 for climate). In the case of NRR these include improvements in water quality (Lehtoranta & Louhi, 2021), carbon sequestration, prevention of natural disasters and protection of cultural heritage (European Union, 2018).

Fostering policymaking based on sound scientific evidence requires scientists to be more proactive in public communication (see Fuentes, 2024; Garrard et al., 2016; Nelson & Vucetich, 2009). This requires (a) balancing evidence to distil the emerging best available evidence; (b) reflecting and communicating complexity, uncertainty and gaps in knowledge in accessible, trustworthy, yet not confusing ways (see also Velado-Alonso et al., 2024); and (c) acknowledging a diversity of opinions while identifying narratives that address societal consensus. Here, one must admit that total certainty is unfeasible in most areas of science, but uncertainty should not be used as an opportunity for delaying action. Importantly, the experience from the NRR case provides another indication that societal and political actors take scientists more seriously when they communicate on the basis of their expertise as reliable knowledge brokers.

Universities and research institutes should invest in generating a favourable environment to support science–policy and science–society interactions, in a coordinated and systematic way. This includes extension and outreach faculty members whose job is to aid in science communication and support to local communities, and where the faculty receives credit and recognition in doing so (Buys & Rennekamp, 2020). Universities and research institutions should dedicate science–policy coordination and communication staff to facilitate the interactions between scientists and policymakers. As the complexity of environmental problems and the volume of scientific literature grow, meta-analyses, scientific reviews and other forms of knowledge synthesis are invaluable. However, yet another step is essential, which is to interpret and communicate science in accessible formats, as done widely in health research, in order to effectively inform public debates and to debunk misinformation (Garrard et al., 2016). We therefore encourage scientists who work on sustainability topics to be proactive and to ask for institutional support and training to help avoid communication pitfalls or biases. For policymakers, we recommend to use scientific evidence and engage scientists toward much needed, ambitious and robust environmental policies—and in the EU, making use of the 'science-for-policy' interface that was recently initiated by the European Commission exactly for this purpose.

7 | CONCLUSION

Sustainable governance of land and sea requires large-scale environmental policies. Synergies and trade-offs will always emerge between nature restoration and economic use of land, sea and biodiversity. Science and scientists have a pivotal obligation not only to provide evidence through their research but also to synthesise evidence from diverse findings. When false evidence claims are employed to support the policy interests of lobby groups, scientists should assume the mandate of debunking misleading information and speak up as honest brokers. We can speak with authority when we draw upon our own expertise. To this end, we should collaborate across disciplines, communicate complexity and uncertainty, and acknowledge different viewpoints. To address complex societal challenges, both science and science communication are imperative to inform evidence-based policy.

AUTHOR CONTRIBUTIONS

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AFFILIATIONS

[1]Department of Biodiversity and People, UFZ – Helmholtz Centre for Environmental Research, Leipzig, Germany; [2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany; [3]Institute of Biodiversity, Ecology and Evolution (IBEE), Friedrich Schiller University Jena, Jena, Germany; [4]University of Leipzig, Leipzig, Germany; [5]Helsinki Sustainability Center, University of Helsinki, Helsinki, Finland;

[6]Aquatic Ecology, Faculty of Biology, University of Duisburg-Essen, Essen, Germany; [7]Department of Biology, University of Turku, Turku, Finland; [8]Finnish Museum of Natural History, University of Helsinki, Helsinki, Finland; [9]Institute of Biology/Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle, Germany; [10]Museum für Naturkunde—Leibniz-Institut für Evolutions- und Biodiversitätsforschung (MfN), Berlin, Germany; [11]Faculty for Law and Economics, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany; [12]Department of Economics, UFZ—Helmholtz Centre for Environmental Research, Leipzig, Germany; [13]Department of Physiological Diversity, UFZ—Helmholtz Centre for Environmental Research, Leipzig, Germany; [14]Department of Biology, University of Prince Edward Island, Charlottetown, Prince Edward Island, Canada; [15]Canadian Centre for Climate Change and Adaptation, University of Prince Edward Island, St. Peter's Bay, Prince Edward Island, Canada; [16]School of Climate Change and Adaptation, University of Prince Edward Island, Charlottetown, Prince Edward Island, Canada; [17]Faculty of Agricultural and Environmental Science, University of Rostock, Rostock, Germany; [18]Joint Research Centre (JRC), European Commission, Ispra, Italy; [19]Udall Center for Studies in Public Policy & School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona, USA; [20]Department of Biology Faculty of Sciences, University of Porto, Porto, Portugal; [21]Cimar and Department of Biology, Faculty of Sciences, University of Porto, Porto, Portugal; [22]Institute of Nature Conservation Polish Academy of Science, Krakow, Poland; [23]Faculty of Experimental Sciences, Centro de Estudios Avanzados en Física, Matemáticas y Computación, Universidad de Huelva, Huelva, Spain; [24]Estación Biológica de Doñana, Consejo Superior de Investigaciones Científicas, Sevilla, Spain; [25]Department of Conservation Biology and Social-Ecological Systems, UFZ—Helmholtz Centre for Environmental Research, Halle, Germany; [26]Institute of Biological Sciences, University of the Philippines in Los Baños (UPLB), Laguna, Philippines; [27]INRAE-DYNAFOR, Castanet-Tolosan, France; [28]Leibniz Institute for Vegetable and Ornamental Crops (IGZ), Großbeeren, Germany and [29]Department of Environmental Politics, UFZ—Helmholtz Centre for Environmental Research, Leipzig, Germany

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ORCID

Guy Pe'er https://orcid.org/0000-0002-7090-0560
Jana Kachler https://orcid.org/0000-0003-0536-2820
Irina Herzon https://orcid.org/0000-0002-8884-0500
Daniel Hering https://orcid.org/0000-0002-5436-4753
Anni Arponen https://orcid.org/0000-0002-6721-7795
Laura Bosco https://orcid.org/0000-0001-6616-2641
Helge Bruelheide https://orcid.org/0000-0003-3135-0356
Elizabeth A. Finch https://orcid.org/0000-0002-7031-5708
Martin Friedrichs-Manthey https://orcid.org/0000-0002-0132-7799
Gregor Hagedorn https://orcid.org/0000-0001-7023-7386
Bernd Hansjürgens https://orcid.org/0000-0002-5650-8300
Emma Ladouceur https://orcid.org/0000-0002-4943-4358
Sebastian Lakner https://orcid.org/0000-0002-5122-8924
Camino Liquete https://orcid.org/0009-0006-8894-2044
Laura López-Hoffman https://orcid.org/0000-0002-8457-8162
Isabel Sousa Pinto https://orcid.org/0000-0002-9231-0553
Marine Robuchon https://orcid.org/0000-0001-5873-2915
Nuria Selva https://orcid.org/0000-0003-3389-201X
Josef Settele https://orcid.org/0000-0002-8624-4983
Clélia Sirami https://orcid.org/0000-0003-1741-3082
Nicole M. van Dam https://orcid.org/0000-0003-2622-5446
Heidi Wittmer https://orcid.org/0000-0001-6966-7258
Aletta Bonn https://orcid.org/0000-0002-8345-4600

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Table S1. Key examples of organizations, places and texts where claims were made against the Nature Restoration Regulation (NRR) and Sustainable Use Regulation (SUR) that are based on misinformation.

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