Role of science and scientists in public debates around environmental policy negotiations: the case of nature restoration and agrochemical regulation in the European Union

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Abstract

1) Halting biodiversity loss, mitigating global warming, and maintaining the long-term viability of rural and urban areas require urgent actions. Environmental policies are being proposed in several countries to reach these targets. However, these proposals often trigger highly polarised public debates based on pseudo-scientific claims, raising concern about the increasing impact of misinformation on policy-making.
2) Here, we analyse the role of science and scientists in the public debate around two pieces of legislation that were recently proposed in the EU as part of the Green Deal, namely the Nature Restoration Law (NRL) and the Sustainable Use Regulation of plant protection products (SUR).
3) First, we examine key claims against these two legislative proposals, and compare them with the scientific evidence. We show that these claims fail to consider ample evidence that restoring nature and reducing the use of agrochemicals are essential for maintaining long-term agricultural production and enhancing food security. The critics further failed to acknowledge that the NRL 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, accompanied by 6,000 signatures by scientists, may have influenced the public debate around the policy proposals. We contrast the role that scientific evidence has played in the fate of the NRL, which may eventually be adopted, against the fate of the SUR which was rejected by the European Parliament.
5) We draw lessons from these two cases, illustrating the global tension between environmental protection and economic-driven interests to spread and use misinformation. We conclude that scientists can play a critical and proactive role in making scientific evidence more accessible and available to the general public and policy makers for informed decision making. We further recommend policy makers to use scientific evidence and engage scientists toward much needed, ambitious and robust environmental policies.

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 production, require us to reduce the human pressures driving current crises and restore nature's capacity to recover and deliver life-support services.

However, pressures to intensify the use of land and sea are still growing. 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, bodies involved in already implemented policies are under increasing pressure to deregulate (Ruggiero et al, 2021; Gasparri et al, 2015). Policy processes around the world are being hijacked by political considerations, sometimes in the name of science but often using pseudo-scientific claims. For example, Samet & Burke (2020) document the pressures on the US Environmental Protection Agency to deregulate pollution control by reducing the agency's research capacity and altering long-established scientific protocols. Scientists across disciplines are concerned that public debates and policy processes at all levels are being increasingly polarised based on contested claims, and potentially disrupted by misinformation (Yang et al., 2017). In particular, social media are able to effectively spread misinformation as they circulate contents 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 COVID19 (Hartley & Vu, 2020). The problem is becoming increasingly dominant in the field of environmental policy, in times when numerous new targets for national and international policies are being set and ratified nationally (e.g. Kunming-Montreal Biodiversity Framework (Convention on Biological Diversity 2022)). Environmental protections are portrayed by some stakeholders 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 should be operationalized to support better governance and decision-making processes (Cook et al., 2013; Langer et al., 2016). This is becoming increasingly difficult since actors involved in misinformation campaigns have been developing increasingly sophisticated communication strategies, *inter alia* by using claims that seem to be based on science - but practically are not scientific or even go against science (e.g. Adams et al., 2023; Farrell et al., 2019; Swire-Thompson & Lazer, 2022). However, public debates usually occur over relatively short periods of time. Consequently, scientists who want to weigh in on the debate need to provide a rapid synthesis of unbiased expert opinions based on best available

evidence, while maintaining a reliable representation of complexities and uncertainties. The process of debunking misinformation also requires 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 Law (NRL) and the Sustainable Use Regulation (SUR), as a case study. First, we examine the eight most common arguments made against the NRL and SUR, and compare these claims with scientific evidence. We then discuss the role scientists played in the public debates around these negotiations, in particular through the publication of an open letter with expressed support from 6,000 scientists (Pe'er et al. 2023). Finally, we derive lessons for the scientific community on the role of science and scientists in contributing to evidence-based policy, and for policymakers and other stakeholders on the use of the best available science in political contexts.

The Nature Restoration Law (NRL) 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 percent of so-called 'Sites of Community Importance' sites that are presumably protected, are in unfavourable or poor condition (European Environment Agency, 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). These examples illustrate an overall environmental crisis.

The European Green Deal (European Commission, 2019) responds to this crisis by providing an ambitious long-term strategy to protect and enhance the EU's natural capital. It aims at (i) preserving and restoring ecosystems and biodiversity, as reflected in the EU Biodiversity Strategy for 2030 (European Commission, 2020a); (ii) developing a fair, healthy and environmentally friendly food system, represented in the Farm to Fork Strategy (European Commission, 2020b); and (iii) reaching 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 NRL and SUR.

The Nature Restoration Law (NRL; European Commission, 2022a) aims at establishing effective restoration measures on habitats protected under the Habitats Directive that are not in good condition (40% by 2030, 60% by 2040 and 90% by 2050) and sets targets to ensure the resilience of food systems (agriculture and fisheries; for an in depth analysis of the NRL see Hering et al. 2023). It includes quantitative targets, timelines, wide geographical coverage and implementation details (e.g. indicators and monitoring requirements) to track progress. It addresses the weaknesses of the present policy framework, which is based on soft voluntary measures - an approach that has so far failed to protect biodiversity and ecosystems (European Environment Agency, 2020; Rigal et al., 2023). The NRL can be considered a global landmark as the first legally binding instrument to implement the Global Biodiversity Framework across borders, i.e., across all EU member states.

The Sustainable Use Regulation of Plant Protection Products, a.k.a Sustainable Use Regulation (SUR; European Commission, 2022b), primarily aimed to reduce the overall use and risk from chemical pesticides by 50%, and to reduce the use of more 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 as well as 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 all 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 NRL and the SUR during 2023 (Euronews 2023). Various societal actors and policymakers argued that the NRL and SUR were placing obstacles to a swift recovery of European economies from recent crises (including Covid19 and the war in Ukraine), in the face of slowed economic growth and increased inflation. There were claims that the NRL 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. Despite the somewhat similar claims against both, the two policies had different fates. The NRL was negotiated among Parliament Members from June to November 2023, its final version was voted favourably in November 2023, and it is expected (and hoped) to pass the final approval stage in February 2024. The SUR was rejected altogether in November 2023.

Key claims against the NRL and SUR and their scientific analysis

Here we analyse eight key claims recurrent through the campaign against the NRL and SUR, and compare them with scientific evidence gathered by our group of multi-disciplinary experts.

1. Land taken out of production

One key claim against the NRL 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 NRL initially proposed that at least 10% of the EU's agricultural area should be covered with high-diversity landscape features (Article 14). 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, 2022e).

However, the claim that the NRL would take an extra 10% of agricultural land out of production was erroneous. First, the 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 7% target (e.g. 2 km of hedgerows on 100 ha arable land equals 4%). Moreover, during the early stages of the NRL's negotiations, "high-diversity landscape features" were already redefined in a way that allowed some level of productive activities. In its final reading, the NRL focused entirely on habitat types in the Habitats Directive, including several grassland habitat types that depend on the maintenance of extensive farming practices.

Secondly, it is crucial to recognize that some farmland areas are already being "taken out of production" in the EU, but not due to nature restoration efforts. Land abandonment occurs in marginalised regions where regional socio-economic viability is undermined (Alliance Environment, 2020). This is particularly true for "High Nature Value" farmlands, where CAP support is insufficient to prevent the abandonment of the least productive land (Scown et al., 2020; Pe'er et al., 2021). Finally, the 10% claim does not affect farmers directly: the targets are rather set for Member States (who have much flexibility on how they set their own national targets), but farmers who contribute to this target would do so on a voluntary basis. Importantly, this approach will 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).

By restoring existing non-productive habitats and some low-productive areas, the NRL can enhance public goods such as water purification, carbon sequestration, erosion control, flood prevention and landscape amenity (e.g., Petit & Landis, 2023; Pywell et al., 2015; Tscharntke et al., 2012; Tamburini et al. 2020), while limiting negative impacts on farm profitability. In marginal areas facing socio-economic challenges, increased public-level benefits could actually contribute to slowing down land abandonment (Brady et al., 2017).

2. Yield losses

A second claim asserted that the NRL and SUR would result in yield losses, and therefore a decrease in agricultural production. This claim was primarily based on the assumption that the SUR would result in a full 50% reduction in pesticide use (Article 4) 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). Indeed, pesticide reduction is not a measure implemented in isolation but rather associated with other practices such as precision agriculture or integrated pest management. Accordingly, it has been shown 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 integrated management practices, such as implementing diversified crop rotation (Deguine et al., 2021; Lechenet et al, 2014). In addition, 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).

Furthermore, those studies estimating that the SUR would reduce crop yields failed to take into account the positive feedback pesticide reduction would have on yields. Indeed, losses of biodiversity and associated ecosystem services (Beckmann et al., 2019; IPBES, 2018), as well as their combined effects with climate change (Seppelt et al., 2020), are among the main drivers of yield losses. For example, yield of about 50% of the EU land cultivated with pollinator-dependent crops is already affected by a deficit in pollinators (European Commission, 2022d) - risking pollinator-dependent crops at an economic value ranging between €7-18 bil./year, 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).

Further yield losses are affected by poor soil conditions in more than 60% of the EU, due to reduced soil biodiversity, pollution, loss of organic matter, compaction, salinization, and soil sealing (Veerman et al., 2020; JRC, 2023). Finally, climate change also increases the severity of pest infestations (Lenton et al., 2019; Harvey et al, 2023).

By restoring landscapes, biodiversity and soils, the NRL and SUR aim at mitigating long-term risks of yield loss. Indeed, ecosystem protection and restoration has the largest potential for both mitigating climate change and protecting biodiversity (Pörtner et al., 2021).

Moreover, increasing functional diversity has the potential to mitigate the negative impacts of climate change on crop production (Dainese et al., 2019 and references therein). However, this requires implementing agroecological practices, such as maintaining semi-natural landscape features (e.g., Petit & Landis, 2023), diversifying crops, employing soil protection and restoration measures, and implementing agroforestry (Reganold & Wachter, 2016).

3. Food insecurity

A third claim asserted that by taking land out of production and hampering yields (see two previous sections), the NRL and SUR would increase global food insecurity. This claim rested on the EU's central role in world markets. Indeed, 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 take into account that EU food production is not the only driver of global food security. Rather, key drivers of food insecurity such as 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 (Holt-Giménez et al., 2012; FAO et al. 2021; 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%) (EU Commission, 2023); and most of the grain produced in the EU is used to produce animal feed (62.4% in 2020/21; European Commission. Directorate General for Agriculture and Rural Development et al., 2020; Lakner, 2023). An increasing amount of land is also used for biofuel production, which leads to increased food prices, making them less accessible to the poorest in society (Lakner, 2023). Finally, the EU heavily depends upon imports of many products including soy (used mostly as feed), palm oil, oil seeds and maize, leading to substantial use of land and resources in the global south - and imports into the EU are increasing (European Commission 2023).

Consequently, the most efficient way for the EU to contribute to both local and global food security is not to increase production but rather to reduce meat and dairy production, meat overconsumption (Costa et al., 2022), food waste (Parfitt et al., 2010; Shepon et al., 2018), and biofuel production (Lakner, 2023). In Germany alone, there is approximately 12 million tonnes of food waste, of which 7 – 7.6 million tonnes is potentially avoidable (Schmidt et al., 2019). Retailers, among others, serve as a key barriers in overcoming waste and food distribution problems, by countering economic incentives that currently discourage efforts to achieve zero food waste (Koester, 2014). A legislative framework for sustainable food systems (FSFS), which was originally due for publication in autumn 2023, was key to achieve such transformations of food consumption patterns. The combination of the FSFS, the NRL and SUR would have therefore contributed to reaching environmental objectives without jeopardising food production, let alone food security (Röös et al., 2022).

4. Fishing restrictions

A fourth claim, which targeted the NRL only, asserted that it would have a negative impact on fisheries due to limitations and changes in fishing areas. This claim was based on the fact that NRL 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 the fact that the main risks to fisheries originate from the combination of unsustainable fisheries and climate change (Moerlein and Carothers, 2012; Portner and 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 very small number of fisheries. Even when affected, fisheries can be compensated through appropriate subsidies (Greenstreet et al., 2009; Suuronen et al., 2010).

Furthermore, 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). Indeed, MPAs 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 biggest challenges that commercial fisheries will face in the future (Pendleton et al., 2018).

By restoring EU MPAs that are currently inadequately managed or insufficiently protected (Dureuil et al., 2018; Perry et al., 2022), the NRL can therefore benefit both biodiversity conservation and fisheries activities. “High-risk” fishing practices currently take place in over 80% of the total area of MPAs in Europe and the UK (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 socioeconomic 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 few marine areas, the NRL 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.

5. Income and job security

Another claim was that the NRL and SUR would “kill jobs”. Job security is indeed a key topic since employment in agriculture has continuously been declining during the last decades. Between 2005 and 2020, there has been a decline of 37% in the number of farms in the EU, reaching 9.1 million farms in the EU in 2020 (i.e., 5.3 million fewer than in 2005; Eurostat, 2022). Some publications on 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).

However, these assessments have been criticised due to their conceptual and practical limitations (Candel, 2022). 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. More importantly, they ignored the key factors affecting jobs in agriculture and fisheries. Indeed, the main reasons for the decline in the number of farmers are structural changes (i.e., increasing centralization) 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). Current policies and the replacement of labour by technologies have also 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).

The most efficient way to ensure job security in the agricultural and fisheries sectors is to improve the resilience of small- and family-businesses, improve the distribution of existing subsidies, promote sustainable production, and generate greater benefits by shortening value chains (e.g., direct marketing). By restoring ecosystems and their multiple uses, the NRL could contribute to more sustainable production but also has the potential to create new employment, through new models of production (e.g. paludiculture) (Temmink et al., 2023). Indeed, 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 NRL 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 MSs in mobilising additional funding (see also Hering et al. 2023 for NRL). Highlighting job losses while ignoring both the drivers of unemployment and the potential for job-creation is therefore, at best, misleading.

6. Burden on society

Another key claim was that the NRL and SUR would generate new restrictions that would increase the burden on society, in a period where - due to recent and ongoing crises - 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).

However, in the long term and on much larger scales, society pays twice for the unsustainable way in which we use land- and sea-scapes, 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 e.g. 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). Pesticide use also generates a dramatic burden in terms of human health, as illustrated by the increased incidence in Parkinson's disease as a result of 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 NRL and SUR can have economic benefits for society 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 €1,860 billion. This is a cost-benefit ratio of 1:12 in favour of benefits (European Commission, 2022c). Moreover, restoring carbon-rich ecosystems provides significant economic benefits through mitigation of 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 euros (Röhr et al., 2016) and the value of the carbon stock of European forests has been estimated at €1,493/ha (€783-3,468/ha) (Raihan et al., 2021). Beyond monetary value, biodiversity and associated ecosystem services are central to physical and mental wellbeing across a range of environments, including urban spaces (Maes et al., 2021; Marselle et al., 2021; Methorst, Bonn, et al., 2021; Methorst; Rehdanz, et al., 2021), and support intrinsic and relational values (IPBES, 2022; Pascual et al., 2017) and other dimensions of wellbeing (Dasgupta, 2021). As a result, when considering the number of beneficiaries, the NRL and the SUR represent a cost-efficient investment rather than a burden for society.

7. Ukraine war

A related claim to the 'burden on society' was that one cannot place new burdens in times of a 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, wheat prices decreased to around €300/t by January 2023. Due to increased exports by Russia and maintained deliveries by Ukraine, supply levels stabilised in the second half of 2023. Based on the grain-deal between Russia, Ukraine and Turkey, the exports by Ukraine, and thereby the global grain supplies were stabilised (Götz & Svanidze, 2023). Despite the termination of the grain-initiative by Russia on July 17th 2023, the situation of the global markets has largely stabilised. 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, too *low* prices in the Eastern EU and a claimed regional *oversupply* of Ukrainian grain led the EU Commission to *restrict* deliveries of Ukrainian agricultural commodities from March 2023 onwards. This situation, and the decision of the EU Commission therefore contradict the claim that Europe is facing a severe scarcity of commodities due to the war.

Thus, the war in Ukraine offers no argument to delay sustainability transition, including nature restoration, certainly not on the grounds of grain scarcities. 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, n.d.). On the contrary, crises could be wisely used as a window of opportunity, to foster a more rapid transition towards sustainable socio-economic arrangements.

Finally, if food scarcity would be in the centre of EU policies, other measures are shown to be more effective in improving food and energy resilience in times of the ongoing war in Ukraine - especially by fostering a reduction in the demand of both food production and energy for transport and infrastructure development (Creutzig, 2022; Sun et al., 2022). Other 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). The Green Deal, and the SUR and NRL therein, should therefore be regarded not as a burden in times of war but rather as means to foster transition to sustainable 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 (Iacobuță et al., 2022).

8. Renewable energy

A final claim that was made against the NRL was that it will undermine renewable energy in Europe, particularly biofuel production. Naturally any policy or regulation that affects land-use would affect other land-uses, and hence possibly resulting in conflicts or tradeoffs. It is also important to acknowledge the role of forest biomass in reducing fossil fuel use 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 versus other uses, including 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 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). While burning residues and post-consumer wood are likely to have the highest additionality, since they avoid the competing needs for forest biomass , as much as half of wood burnt in the EU is "primary woody biomass", which totals to about 40% of the EU's renewable energy (Camia et al., 2021). The practice 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.

Even if the restoration targets are fully achieved under NRL, they do not preclude use of the restored and remaining forests for multiple products, including that for bioenergy, primarily from the residues and side-streams. It is critically important that the EU and other regions restrict burning of forest biomass, especially primary woody biomass and particularly so from primary forests, from its renewable energy targets and divert subsidies into zero-emissions renewable energy and energy efficiency measures.

Numerous assessments highlight that the most important 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). If anything, the situation should be analysed in reverse: to prevent undermining sustainable food production as well as renewable energy targets, most efficient climate mitigation options should be implemented - including nature restoration.

Synthesis of claims and scientific evidence

Notably, most claims against the NRL and SUR were linked to agriculture and food production, and based on short-term arguments such as 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 in stark contrast to the scope of scientific evidence (Table 1). Some claims also misinterpreted the actual nature of measures in the proposals, such as the fact that the NRL focuses primarily on improving the status of protected habitat types rather than the expansion of protected areas. Our synthesis of scientific evidence highlighted the importance of restoring good ecological conditions on habitats, and the need to reduce the pressures on ecosystems through the overuse of agrochemicals. It suggested that benefits of NRL and SUR would encompass long-term production capacity of land and marine environments, food security, job creation, innovation, and sustainable production models.

Table 1: *synthesis of the claims against the NRL and SUR and key elements of the scientific analysis.*

Claim	**Scientific analysis**
1. NRL will take 10% land out of production	- CAP 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 already negatively impacted by soil degradation, climate change and biodiversity loss - Combining a decrease in pesticide use with agroecological practices is necessary to maintain yield
3. NRL 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. NRL 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 MPAs would enhance yield of neighbouring fisheries
5. NRL 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 CAP investments - NRL and SUR can generate jobs
6. NRL and SUR will place a burden on society	- Restoring nature would cost a total of €154 billions - Benefits of restoring nature are 12 times higher than costs - Climate change and pesticide overuse already are a huge burden on society
7. NRL and SUR are too risky in time of war	- War generated an increase in food and energy prices in 2022 - Markets have rapidly stabilised in 2023 - Reducing food demand and dependencies to energy imports is key to increase resilience
8. NRL undermines renewable energy targets	- There are tradeoffs between increasing forest biomass harvest and other uses/restoration targets - Burning biomass produces emissions and is highly contested for climate change mitigation - NRL could restore natural carbon sinks and mitigate climate change

Role of scientists in the public debate and negotiations of the NRL and SUR

1. Scientists' open letter

The campaign against the NRL and SUR, based on the claims addressed above, originally placed the NRL at risk of rejection, with a 44:44 vote at the environmental committee of the EU's Parliament in June 2023. Responses from scientists included an open letter in favour of the NRL and SUR, delineating the arguments listed above, and signed by 6,000 scientists (Pe'er et al., 2023). Writing this open letter required understanding the two legislative proposals, identifying main claims against these proposals and gathering relevant and unbiased scientific evidence in a short period of time. This was achieved thanks to the collaboration of a large group of multi-disciplinary experts. The open letter was then disseminated through scientific networks, including European (scientific and research) learning societies, which largely contributed to the letter receiving such a high number of signatures. The publication of the open letter was followed by a press conference and invitations for members of Parliament to meet with scientists.

The arguments of the open letter were widely reported by journalists and published in news outlets, and provided scientific support to NGOs and businesses, as well as government agencies and parliamentarians making their case. Notably, many of the arguments in favour of a more ambitious NRL - voiced by major news outlets (newspapers, radio stations and social media) - adopted the arguments made in the scientists' open letter. Societal and political actors seemed more informed and referred to scientific evidence.

2. Toward potential adoption of the NRL

These combined actions of NGOs, businesses, concerned policymakers and scientists moved the next Parliamentary vote toward a tight but favourable outcome for the NRL on 12 July 2023 (336 in favour, 300 against, 13 votes to abstain). The EU Parliament, however, also voted for a large list of amendments proposing a significant watering down of the NRL. The final formulation of the law, following the so-called trilogue negotiations (among the Parliament, the European Council of ministers and the Commission), in November 2023, was much more balanced between the original Commission's proposal and the Parliament's proposal. As of February 2024, it is anticipated that the EU Parliament will vote, possibly favourably, for the NRL on 24.2.2024.

Nonetheless, some misleading arguments against the NRL still remained in public debates and were carried into the final formulation of the NRL. For example, Article 22a gives Member States the possibility to place an "emergency brake" on implementing the NRL in agricultural areas, stating that "*Where an unforeseeable, exceptional and unprovoked event has occurred that is outside the control of the EU, with severe EU wide consequences on the availability of land required to secure sufficient agricultural production for EU food consumption, the Commission shall adopt implementing acts which […] may temporarily suspend the application of […] Article 9"* (Agriculture).

This formulation is based on the false premise that the EU lacks agricultural areas to sustain sufficient production for its own food consumption. Yet with circa 70% of arable area used for feed and fuel, and with overproduction of many non-essential products, it is extremely unlikely that the conditions described above will occur in the foreseeable future: this would require vast swaths of arable land to become unusable. By contrast, the derogations taken in 2022 and 2023 (and now proposed for 2024), allowing farmers to be exempted from maintaining a minimum share of agricultural areas as non-productive areas - to retain biodiversity and essential ecosystem services - indicate a very high likelihood that Member States will try to implement this clause.

3. Rejection of the SUR

The case of the SUR was politically more complex. The Parliament had already pressured the Commission to generate a new SUR proposal that was significantly weaker with respect to environmental targets than the original version (June 2022). Despite this significant watering down of the proposal, the SUR was rejected altogether on 22 November 2023, with a majority of 299:207:121 (against: in favour: abstain). In practice, this will delay the negotiations on SUR by several years. This occurred despite 1.1 million EU citizens who signed a call to install the SUR (see www.savebeesandfarmers.eu/eng), and the hundreds of European scientists who signed an open letter appealing the EU not to delay its approval (Candel 2022).

4. Lessons from the compared fate of the NRL and SUR

The differing paths of negotiations over the NRL and SUR warrant a reflection on why one legal proposal was closer to adoption while the other was rejected, as well as the role of science and scientist. Three main differences stand out.

First, the NRL and SUR differed in terms of consensus level within society. Indeed, there is a relative consensus both in society and science for the need to restore nature. This was shown in a Eurobarometer survey among over 27,000 citizens (Kantar, 2020), where 94% of citizens expressed that protecting the environment is important for them. Similarly, the EU consultation on "modernising and simplifying the CAP" confirmed that a majority of farmers were calling for an improvement in the environmental performance of the CAP (ECORYS, 2017). In 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 disease. 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 NRL and SUR differed in terms of perceived cost and benefits. Indeed, most proposed measures under NRL were voluntary for affected actors, whereas measures under SUR were associated with restrictions. Moreover, arguments in favour of the SUR were mostly about long-term health benefits for consumers, whereas counter arguments focused on short-term fears regarding food insecurity. For instance, food shortages triggered by covid and the war in Ukraine have had major impacts on European consumers and their perception of food security. Moreover, decades of reliance on pesticides have resulted in a high risk-aversion reaction from 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 NRL.

Third, the role of lobbies is likely to have strongly differed in the cases. If approved, the SUR regulation would have had a direct impact on agrochemical producers, potentially leading toward reduced dependence of farmers on such chemicals. Deguine et al. (2021) have demonstrated how the agrochemical industry has been shaping the distorted adoption of IPM by lobbying, marketing, and manipulation. Goulson (2020) also highlights efforts of the agrochemical industry to block initiatives towards the reduction of pesticide use. 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., 2020 and references therein).

Discussion

The debates around the NRL and SUR legislation are not unique to Europe. Globally, land is becoming an increasingly limited resource, and environmental conflicts are worsening. Consequently, in many parts of the world, environmental legislation and policies have been facing increased resistance, including pressures for deregulation.

The use of misinformation in environmental debates is becoming increasingly common and can be evidenced globally. Examples are the use of fake controversies and misleading arguments to aid the dismantlement of environmental conservation policies in Brazil (Rajão et al. 2022; Forti et al. 2023); inaccurate claims on the impacts of agrochemical products by those working within the industry (Murray et al. 2000), or misleading the public about the causative link between fossil fuel use and climate warming by members of the fossil fuel industry (e.g. Farrell et al., 2019; Supran et al., 2023).

However, as demonstrated by Schmid & Betsch (2019), effective rebuttal strategies of misinformation do work. The case of the NRL provides evidence to this point: if adopted, it would demonstrate a positive contribution of the scientific community, among others through the open letter (Pe'er et al. 2023) - by debunking misinformation, highlighting beneficiaries versus losers, and addressing questions of broad societal interests. In this way, the scientific community can help tackle misinformation and mitigate its negative effects.

Lessons toward a constructive dialogue

Societal and political debates are inherent elements of societal transformations, and will become increasingly important in upcoming urgent, cross-sectional transitions such as those needed towards more environmentally sustainable land and water use practices (Bennett et al., 2019). 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 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 NRL these include improvements in water quality (Lehtoranta & Louhi, 2021) and protection of cultural heritage (European Commission, 2018). Here scientists can contribute to building a more positive dialogue that highlights cross-sectional benefits, and help shape the messaging.

Conflicts and tradeoffs, especially between nature restoration and economic activities, are not new either. They need to be identified and acknowledged, but there is a considerable body of experience and literature studying such conflicts, as well as avenues to resolve them (e.g., Lécuyer et al., 2021; Oppla, 2023). Here, scientists can help highlight that complexity doesn't have to stand as a barrier toward solutions.

Recommendations to scientists and scientific institutions

1) The role of science and scientific synthesis & interdisciplinarity

The complexity of environmental problems and the amount of scientific literature is ever growing; and for knowledge brokers it is increasingly difficult to extract the essential information and to aid policy makers draw conclusions in the face of contradicting scientific arguments and positions. To this end, scientific reviews, meta-analyses, and other forms of knowledge-synthesis can have a high potential to assist policy-makers, to inform debates, and to debunk misinformation.

Similarly, understanding and addressing misinformation requires better knowledge of the mechanisms by which misinformation is generated and disseminated (Gundersen et al. 2022). Closer collaboration of natural, social and psychological scientists with expertise in

behavioural psychology may prove powerful to debunk misinformation in order to ensure both a rigorous scientific evidence base as well as a science-oriented process and debate structure. Another challenge is that engaging with policy debates requires a different way of communication and This requires training in science communication (see below).

2) **The power of science-communication**

We encourage scientists to be more proactive in publicly communicating their expertise (see Garrard et al., 2016, Nelson & Vucetich, 2009). The debate around the NRL demonstrated the paramount role of science, and scientists, in countering misinformation. Science communication 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; (c) acknowledging a diversity of opinions while identifying narratives that address societal consensus; and (d) more rapid action than scientists are generally accustomed to. Moreover, it is important to understand the logic behind generation of misinformation and its effects on societal actors, as otherwise one cannot identify and reject it. The experience from the NRL case demonstrated that scientists can accept the mandate to communicate their expertise, and where misinformation is spread, to correct errors and address misconceptions. In doing so, scientists can serve as reliable knowledge brokers and environment advocates (see Nelson & Vucetich, 2009), in the same way that medical doctors are authorised to serve as health advocates (Garrard et al., 2016).

3) career development and institutional support

The capacity of scientists, and/or their ambition, to engage at the science-policy interface may be limited by academic and scholarly norms which privilege the number of scientific publications and citation scores over public engagement. Progress will require scientists to receive credits for these types of activities. The EU might wish to emulate the example extension faculty in US Land Grant universities, whose job it is to provide information to and support to local communities, and who receive credit and recognition for doing so (Buys & Rennekamp 2020). Further, since involvement in science-policy interactions is time demanding, technical support should be provided within institutions. Such support may also include the hiring of legislative and policy staff to facilitate the interactions between scientists and policymakers - and to insulate scientists from perceptions of activism.

Recommendations to policymakers

The positive vote for the NRL points at a promising lane for political action. In view of the public's support of nature restoration, we encourage governments globally to install protection and restoration laws at the earliest possible point - even if small sectors oppose it - and identify effective means of communication to, and with, the public.

We encourage the EU to progress the Green Deal as rapidly as possible, and for other national governments to advance holistic policy packages to address the current environmental crises. Scientists across many relevant disciplines can provide the much-needed evidence, and are keen to support where possible. Yet it is the job of decision-makers to take responsible decisions, to secure optimal policy design, and to make implementation feasible. The call of over 6000 scientists (Pe'er et al. 2023), to progress the NRL, SUR and the Green Deal, thus remains relevant - for Europe and globally.

Conclusion

Nature and its resources provide life support for all people and affect our economy, livelihoods, and culture, in Europe and around the world. Responding to the crises of biodiversity loss and climate change requires sound, evidence-guided policymaking. Scientists have a paramount

responsibility as knowledge brokers to support informed decision-making. When evidence is unclear, or when misinformation is spread to serve narrow interests, scientists must find ways to effectively and accessibly provide balanced evidence, and policy makers must use scientific evidence and engage scientists to make decisions. Science, policy and practise are key to secure the protection, restoration, and sustainable use of biodiversity and a healthy planet.

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