OPERATIONALIZING THE IUCN RED LIST OF ECOSYSTEMS IN PUBLIC POLICY

Alberto J. Alaniz\textsuperscript{1,2,3} | Jorge F. Pérez-Quezada\textsuperscript{2,4} | Mauricio Galleguillos\textsuperscript{2,5} | Alexis E. Vásquez\textsuperscript{6} | David A. Keith\textsuperscript{7,8,9,10}

\textsuperscript{1}Centro de Estudios en Ecología Espacial y Medio Ambiente—Ecogeografía, Santiago, Chile
\textsuperscript{2}Departamento de Recursos Naturales Renovables, Universidad de Chile, Santiago, Chile
\textsuperscript{3}Departamento de Gestión Agraria, Facultad Tecnológica, Universidad de Santiago Chile, Santiago, Chile
\textsuperscript{4}Instituto de Ecología y Biodiversidad (IEB), Universidad de Chile, Santiago, Chile
\textsuperscript{5}Center for Climate and Resilience Research (CR2), Universidad de Chile, Santiago, Chile
\textsuperscript{6}Departamento de Geografía, Universidad de Chile, Santiago, Chile
\textsuperscript{7}Centre for Ecosystem Science, University of New South Wales, Sydney, New South Wales, Australia
\textsuperscript{8}New South Wales Office of Environment and Heritage, Sydney, New South Wales, Australia
\textsuperscript{9}IUCN Commission on Ecosystem Management, Gland, Switzerland
\textsuperscript{10}IUCN Species Survival Commission, Gland, Switzerland

Correspondence
Alberto J. Alaniz, Centro de Estudios en Ecología Espacial y Medio Ambiente—Ecogeografía, Santiago, Chile.
Email: alberto.alaniz@ug.uchile.cl

Abstract
Threats to ecosystems are closely linked to human development, whereas lack, insufficiency, and inefficiency of public policies are important drivers of environmental decline. Previous studies have discussed the contribution of IUCN’s Red List of Ecosystems (RLE) in conservation issues; however, its applications in different policy fields and instruments for achieving biodiversity conservation have not been explored in detail. Here, we introduce a framework to operationalize the RLE in public policy, facilitating work of governments, practitioners, and decision makers. Our analysis identified 20 policy instruments that could reduce risks to ecosystems highlighted by different Red List criteria. We discuss how RLE could inform the policy process by analyzing different instruments that could be designed, implemented, and modified to achieve risk reduction. We also present practical examples from around the world showing how ecosystem conservation could be improved by operationalizing the RLE in policy instruments. The RLE criteria can inform the policy process by helping to shape objectives and identifying policy instruments that directly address the causes and severity of risks illuminated in Red List assessments. We conclude that RLE could be expanded into a broader holistic spectrum of policy instruments, which could be a key to achieving the ecosystem conservation.

KEYWORDS
assessment criteria, conservation planning, ecosystem conservation, land use planning, policy instruments, prioritization, threatened ecosystems

1 | INTRODUCTION

Species extinction and ecosystem collapse are closely linked to human development, the intensification of production systems and changes in land use (Tilman et al., 2017). To date, most efforts have been at the levels of species and populations, where a great deal of progress has been made using tools such as the Red Lists of Threatened Species and their implementation through guidelines and regulations (Do, Krott, Juerges, & Böcher, 2018; Pimm et al., 2014). In contrast, ecosystem-level
diversity has been neglected, although the recently developed Red List of Ecosystems (RLE) offers an opportunity to accomplish internationally agreed conservation goals such as Aichi Targets and Sustainable Development Goals, and to correct the extinction debt at this level of ecological organization (Bland, Keith, Miller, Murray, & Rodriguez, 2016). Methodological guidelines have been developed to support applications of national and subnational RLE (Bland et al., 2016; Keith et al., 2013) and the initial policy impact has been substantial (Bland et al., 2018); however, there is yet little guidance on how to operationalize RLE in public policy (Keith et al., 2015).

The RLE method comprises five criteria and a series of thresholds to determine an ecosystem’s risk of collapse (an analogous concept to that of extinction for species): (A) reduction in the distribution, (B) restricted distribution, (C) degradation of abiotic functional processes, (D) disruption of biotic functional processes, and (E) quantitative analysis of the risk of collapse (Keith et al., 2013). Having a robust method to classify ecosystems, recognizing their spatially explicit dimension and knowing the sources of threat, can support the application of policies that could improve ecosystem-level outcomes for biodiversity conservation (Keith et al., 2015). Our aim is to present a systematic framework to governments and practitioners for operationalizing RLE in policy instruments associated with different policy fields, such as land-use and socioeconomic planning, national and local conservation, climate change agendas, and production industries (agriculture, forestry, etc.; Rogge & Reichardt, 2016).

2 | OPPORTUNITIES FOR RLE TO INFORM PUBLIC POLICY

Spatial information on the location of threatened ecosystems enables policy, management, and restoration responses to be targeted at particular activities and areas on land, coastal zones, and oceans to reduce their risks. As well, the identification of those ecosystems makes it possible to implement measures appropriate to their territorial context (e.g., land tenure, water catchments, and ocean fisheries). This is important because a significant proportion of ecosystems that face high risks are those close to areas of high human activity with rapid changes in use of land, freshwater, and the oceans (Alaniz, Galleguillos, & Pérez-Quezada, 2016; Alaniz, Carvajal, Núñez-Hidalgo, & Vergara, 2019; Joppa & Pfaff, 2009).

The inclusion of RLE in policy should focus on the development of a policy strategy comprising a series of policy instruments to achieve these objectives within a policy process (Barton, Ring, & Rusch, 2017), which can include the following steps (Evans & Cvitanovic, 2018): (a) identification of the problem, which under the RLE approach has the clear objective “to reduce risks to threatened ecosystems and to maintain the nonthreat status of the other ones,” (b) policy formulation and decision making, focused on a series of policy instruments from different policy fields to address the preceding objective (see Rogge & Reichardt, 2016), (c) implementation, avoiding contradiction, and ensuring consistency and coherence between the instruments. The alignment of the elements of the policy mix should generate a synergistic interaction, being effective in reducing ecosystem risks (Dovers & Hussey, 2013; Evans & Cvitanovic, 2018), and (d) monitoring and evaluation, such that continuous RLE reassessments update the threat status of ecosystems to inform the policy process and required adjustments and modifications (policy learning and adaptation; Evans & Cvitanovic, 2018; Rogge & Reichardt, 2016).

3 | RLE CRITERIA AND POLICY INSTRUMENTS

Each of the RLE criteria for assessing risks to ecosystems has implications for public policy, because the means of abating threats to ecosystems are inevitably founded in management to address the symptoms of risk (Busch & Ferretti-Gallon, 2017; Keith 2015). Next, we discuss how RLE may be integrated into a series of policy instruments designed to abate the drivers of ecosystem degradation. Policy instruments are tools to achieve overarching objectives, as well as techniques of governance that address policy issues (Rogge & Reichardt, 2016). We identified relevant policy instruments by first considering four general types (Rogge & Reichardt, 2016): (a) economic, associated with monetary incentives, taxes, or similar, (b) regulation, associated with laws and regulations to constrain, limit, or prohibit activities, (c) information, associated with promotion of research and development, and (d) preventive, aimed at avoiding or mitigating potential future threats (Figure 1). Within each type, we considered specific instruments that might be used to address symptoms of risk identified by each of the RLE criteria. In Table 1, we suggest how each of the resulting 20 policy instruments may be applied to improve ecosystem threat status.

3.1 | Reduction in the distribution (A)

The loss and fragmentation of habitat are the main drivers of species extinction and ecosystem collapse (Bland et al., 2017; Keith et al., 2015; Pimm et al., 2014). On land, the decline of habitat is generally associated with weak regulation of land-use planning and development activities (Busch & Ferretti-Gallon, 2017; Zarin et al., 2016); however, some substantively regulated jurisdictions still suffer high rates of ecosystem loss (Evans, 2016). Thus, ecosystems threatened under this criterion should be protected by (a) the development and
TABLE 1  Links between Red List criteria that support the threat level of ecosystems and public policy options for addressing respective risks. Each instrument is classified (in parenthesis) based on the following categories: E, economic instruments; R, regulation instruments; I, information instruments; P, preventive instruments (based on Rogge & Reichardt, 2016)

| Criterion                          | Potential threats to biodiversity                                                                                           | Policy instruments and their implications for the conservation of biodiversity                                                                 |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| (A) Reduction in distribution and   | Change of land use and cover resulting from the expansion of productive land uses, infrastructure, and exploitation of habitat resources at the expense of natural cover. Examples include land clearing, abstraction of water from lakes or streams reducing their extent, and seafloor bottom trawling, reducing the extent of benthic ecosystems (some of these processes may also be relevant to assessing risk under criteria C and D). | 1. Land-use, spatial marine, and coastal zone plans (R)                                                                                                                                                     |
| (B) Restricted distribution        |                                                                                                                                                                                      |   - Identify threatened remnant ecosystems (vulnerable, endangered, and critically endangered), delimiting their specific location in the space (in land, coastal, or marine zones).               |
|                                    |                                                                                                                                                                                      |   - Evaluate current land uses based on the threat category of the ecosystems that they affect, considering the distribution of the ecosystem and surrounding areas.                                    |
|                                    |                                                                                                                                                                                      |   - Establish modifications to the permitted land uses and covers based on the threat level.                                                                                                              |
|                                    |                                                                                                                                                                                      |   - From this, actions of prevention, mitigation, or restoration can be undertaken based on the potential impact of the land use on the threatened ecosystem.                                              |
|                                    |                                                                                                                                                                                      |   - Establish regulatory zones on the basis of the threat level, avoiding the confluence of such uses as industrial, residential, and/or productive with a heavy impact on ecosystems with a high threat level. |
|                                    |                                                                                                                                                                                      |   - Constantly reevaluate land-use plans with a view to adaptive management, improving the state of the threatened ecosystems and maintaining those not under threat.                         |
|                                    |                                                                                                                                                                                      | 2. Incentives, taxation, and offsets schemes for conservation aligned with the mitigation hierarchy (avoid > mitigate > offset) (E)  |
|                                    |                                                                                                                                                                                      |   - Where land or sea ownership is private, it is recommended that benefits such as incentives and reduced taxes be focused on impact avoidance, maintaining threatened remnant ecosystems. |
|                                    |                                                                                                                                                                                      |   - If the privately owned property is apt for production uses (agricultural, forestry, trawling, etc.), strategies could be developed to provide for the maintenance of the area covered by the threatened remnant ecosystems to avoid impacts. |
|                                    |                                                                                                                                                                                      |   - Financial benefits could be granted to property owners or leases for changing to more sustainable production practices (e.g., organic, agroecological, and traditional productive systems), mitigating impacts and reducing the edge effect from the surrounding zones. |
|                                    |                                                                                                                                                                                      |   - It is possible to design compensatory actions to offset biodiversity impacts of production activities or development projects, with the type and degree of compensation based on the magnitude of potential impacts and Red List status of affected ecosystems |
|                                    |                                                                                                                                                                                      | 3. Investment projects regulation (R)                                                                                                                                                                      |
|                                    |                                                                                                                                                                                      |   - Implement special restrictions and assessment requirements for development projects that impact their distribution of ecosystems assessed as Near Threatened status under RLE. |
|                                    |                                                                                                                                                                                      | 4. Protected areas and landscape planning instruments (P, R)                                                                                                                                              |
|                                    |                                                                                                                                                                                      |   - Create PA’s to protect ecosystems at high levels of risk, especially those threatened under criterion B, because their highly restricted distribution makes them very vulnerable to changes. |
|                                    |                                                                                                                                                                                      |   - Evaluate the national and subnational PA’s networks, seeking to improve the representation of ecosystems with a significant reduction in their distribution.                                            |
|                                    |                                                                                                                                                                                      |   - Design and implement biological corridors to increase the habitat surface by connecting isolated patches.                                                                                               |

(Continues)
| Criterion | Potential threats to biodiversity | Policy instruments and their implications for the conservation of biodiversity |
|----------|---------------------------------|--------------------------------------------------|
|          | Wildland fires: The occurrence of forest fires can reduce the distribution of fire-sensitive ecosystems (fire may also be relevant to assessments under criteria C and D). | 5. Wildfires management plans (R, P)  
- Monitor the occurrence of fires in threatened ecosystems, identifying areas of latent risk based on the occurrence of events.  
- Reduce the occurrence of fires in threatened ecosystems by limiting human ignition sources during fire seasons (e.g., camping, agricultural burns, and the use of machinery).  
- Implement strategic fuel management zones to reduce spread of fire from or into production assets (especially of exotic plantations) and into threatened ecosystems. |
|          | Climate change can alter the distribution of ecosystems (especially in marine, coastal, and freshwater ecosystems) | 6. Spatially Explicit Climate change contingency plans (P)  
- Anticipate potential changes in ecosystem distribution, and respond opportunistically by implementing spatially explicit policies. Additionally, RLE could contribute to Global Climate Agreements, by identifying target ecosystems of global concern and proposing actions to avoid their collapse due to climate change. |
|          | Water exploitation: Poor management of water flows and volumes can cause shortages and modify the physical processes in ecosystems. | 7. Water rights and ownership (R)  
- The granting of water extraction rights and the use of water flows should consider the threat status of ecosystems connected by water to the extraction sources, and therefore potentially threatened by reduced water supply.  
- Water extraction should be restricted in highly threatened ecosystems. At sites where the impact has already occurred, owners of extraction rights should be required to undertake mitigation and repair measures to restore the characteristics of the affected ecosystem(s).  
- The conservation of aquifers is necessary to support ecosystems threatened by groundwater depletion.  
- Establish protection zones around rivers and other water reservoirs |
|          | Soil loss and erosion: Poor land-use management, associated with activities like livestock farming and forestry, can endanger ecosystems, affecting the amount and quality of the soil as well as plant reproduction. | 8. Soil conservation through regulation of livestock activities (R, E)  
- Regulation of livestock activities in threatened remnant ecosystems to avoid and/or reduce soil erosion.  
- Granting incentives to livestock owners to avoid impacts on or near threatened ecosystems.  
9. Forestry production regulation and policies (R)  
- Exclude large-scale clear-cutting and timber harvest from the immediate surroundings of threatened ecosystems, designing special harvest prescriptions to minimize impacts.  
- Manage the extraction of firewood and woody debris from threatened ecosystems to maintain the organic properties of the soil.  
10. Soil recovery plans (E)  
- Develop legal instruments to promote the recovery of soils in threatened ecosystems using stimulus funding to foster the recovery of degraded soils and measures to rehabilitate and restore the ecosystem. |
| Criterion | Potential threats to biodiversity | Policy instruments and their implications for the conservation of biodiversity |
|----------|----------------------------------|---------------------------------------------------------------------------|
| **Pollution:** Waste disposal can threaten ecosystems by altering the quality of the air, soil or water. | 11. Waste disposal and dispersion laws and regulations (R)  
   • Avoid the disposal of liquid or solid waste near threatened ecosystems.  
   • This will avoid the dispersal of polluting agents directly and diffusely into the ecosystem, changing the chemical characteristics (e.g., pH, salinity, dissolved nitrogen, concentrated heavy metal concentrations, available carbon, etc.). | 12. Air quality standards and laws (R)  
   • Avoid the emission of air contaminants that may drift to threatened ecosystems, which could affect the environmental quality of the ecosystem and the health of vegetation and wildlife. |
| **Climate change driving changes in the functions and/or abiotic characteristics of ecosystems.** | 13. Climate change contingency and adaptation plans (P)  
   • Promote research to analyze future scenarios through models that can estimate the potential impacts and anticipate changes in moisture regimes, temperature, extreme weather events, pH, and salinity in terrestrial and aquatic ecosystems.  
   • Design and implement plans to protect climate refuges, promote low-risk scenarios identified by modeling, and address the level and causes of the threat under this criterion, incorporating flexibility to make future modifications imposed by climate change. |  

| **(D) Disruption of biotic processes and functions** | Biological invasions: The introduction of species incidentally or accidentally can have significant effects on the biotic interactions within and between ecosystem. | 14. Agriculture, forestry, and fisheries species regulations (R)  
   • Policies, procedures, and regulations for the importation of species for production purposes should consider the threat level of ecosystems in a radius of influence from the target site, considering such characteristics as the dispersion range of the species to be introduced.  
   • For species proposed for introduction to support pollination and pest control, test the invasiveness and impact on networks of interaction within threatened ecosystems and link test outcomes to important approval regulations  
   • Minimize accidental dispersion of propagules through customs and quarantine policies, as well production management, making importers and transport entities accountable for controlling the undesired dispersion of invasive species. | 15. Invasive species control plans and hunting laws (R, E)  
   • Control invasive species already present in threatened ecosystems by facilitating access to information and resources to support control and population reduction.  
   • Manage domesticated plant and animal species be controlling their movement and reproduction through registrations, sterilization programs and other measures to avoid the impacts wildlife and vegetation components of threatened ecosystem. |

(Continues)
### TABLE 1  (Continued)

| Criterion | Potential threats to biodiversity | Policy instruments and their implications for the conservation of biodiversity |
|-----------|----------------------------------|------------------------------------------------------------------------------|
| 16.       | Disease control policies and programs for wildlife and domestic animal (R) | • Reduce potential transmission of pathogens linked to ecosystem decline through RLE assessments. Strategies include (a) sterilization and vaccination of domestic species like felines and canines and (b) regulation of the human-dispersed, fungi, other pathogens, and their hosts in natural ecosystems. |
| 17.       | Environmental impact assessment laws and regulation(R) | • Implement production strategies to avoid disruption of biotic interactions among species within threatened ecosystems (e.g., dispersal, stress, reproduction, feeding, nesting, among others) by mitigating barriers to movement and breeding behavior, reducing noise, and so forth. |
| Extinction of key species (ecosystem engineers, trophic or structural dominants, keystone or foundation species, etc.): The reduction of the populations of key species can significantly affect the operation of the ecosystem. | 18. Conservation planning (I, P) | • Conduct studies to advance understanding of the structures of the interaction networks in ecosystems threatened by the disruption of biotic processes and interactions. |
|          |                                                                                 | • Implemented measures to maintain or increase the populations of key species that are undergoing significant reduction. |
|          |                                                                                 | • Assess the Red List status of key species and design and implement recovery strategies. |
|          |                                                                                 | • Design and maintain functional corridors in fragmented landscapes that include threatened ecosystems, promoting genetic flow between populations. |
| (E) Quantitative analysis of the risk of collapse: Sum of threatening processes associated with some of the causes previously set out or with a combination of these. | 19. Scientific funds and monitoring programs (I) | • Resource scientific research and monitoring programs for threatened ecosystems to generate data for parameterizing predictive models that can support strategic management. |
|          |                                                                                 | 20. Action plans and strategies (I) |
|          |                                                                                 | • Use models to explore and compare the outcomes of alternative ecosystem management strategies. These scenarios can help authorities to design and implement suitable and timely strategies to avoid ecosystem collapse. |
3.2 Restricted distribution (B)

Some ecosystems are intrinsically restricted, which makes them very vulnerable to anthropogenic and natural disturbances (Keith et al., 2013). Therefore, ecosystems that are threatened due to their restricted distribution should be managed to avoid disturbances and to maintain suitable environmental conditions at their locations (Auld & Leishman, 2015). In such cases, public or private PA’s can be effective and efficient means of conserving these unique ecosystems, while implementation of effective land-use regulations and plans with ecological objectives, as well as the specific instruments associated, (b) the creation of new protected areas (PA’s) and public–private partnerships, to maintain and recover the spatial extent of threatened ecosystems by restricting intensive land uses within and around them (buffer zones; Table 1), and (c) effective regulation of destructive practices such as of clearing, logging, seafloor bottom-trawling, wetland transformation, and intensive livestock grazing. As an example, regulation through enforcement of law to limit clearing rainforest for expansion of soy plantations in the Amazon Basin (Brazil), significantly reduced deforestation rates between 2008 and 2012 (Busch & Ferretti-Gallon, 2017; Zarin et al., 2016).

3.3 Degradation of abiotic processes (C)

The causes of degradation of abiotic ecosystem components are manifold, such as excessive water extraction from rivers or groundwater, soil erosion, climate change, pollution, and so forth (Keith et al., 2013). Ecosystems could undergo far-reaching changes in some of their abiotic characteristics even if they have not undergone a significant reduction of their distribution, placing their persistence at risk, even if they have provisions in regional or local plans can be important complementary measures (Table 1). In cases where processes other than land use change threaten the persistence of restricted ecosystems, the effectiveness of PA’s will depend on their management plans and efficacy of implementation (IUCN and WCPA, 2017). As an example, Gnarled Mossy Cloud Forest on Lord Howe Island (Australia) has been classified as critically endangered based on their restricted distribution with continuing decline. This motivated the Australian state and federal governments to develop conservation and recovery strategies focused on (a) monitoring and detection of climate change impacts, (b) control and eradication of rats and weeds, and (c) implementation of a quarantine plan (Auld & Leishman, 2015).
not undergone any significant reduction of their distribution (Keith et al., 2013). Actions to maintain the functional dynamics of the ecosystems listed under this criterion should include policies to reduce the intensity, frequency, or spatial extent of the drivers of degradation. One example is the implementation of instruments to manage the volume and timing of water extraction in a river basin to limit impacts on water-dependent forests or wetlands downstream (Keith, 2015). More generally, documenting the number, identity, extent, and values of ecosystems identified as threatened by climate change under criterion C will help quantify public benefit in committing to strong mitigation policies, particularly through emission reductions, as well as identifying refuges for strategic protection into the future. Another example involves climate change adaptation strategies, which are more spatially structured and relevant to local policy instruments over both short and long terms (e.g., provision of economic and technical support for ecosystem restoration, defining clear work chronograms and goals; Pecl et al., 2017; Table 1). For example, in Wellington (New Zealand), climate change adaptation strategies for coastal zones integrate direct interventions through managed retreat, the construction of a seawall and raised reclamation lands (WCC, 2013) to protect coastal and estuarine ecosystems. Plans such as the Comprehensive Everglades Restoration Plan (USA) have proven to be effective for restoring soil conditions and carbon sequestration in the ecosystem (Osborne, Fitz, & Davis, 2017). Similarly, in Windhoek (Namibia), a series of restoration programs achieved return of groundwater levels in the aquifers (Sinclair et al., 2018).

3.4 | Disruption of biotic interactions (D)

This criterion identifies ecosystems at risk from modification of interactions among biota, such as trophic networks, declines of keystone or foundation species, functional processes (e.g., carbon sequestration or nitrogen fixation), ecological interactions, changes to phenological cycles, the arrival of invasive species and pathogens, among others (Keith et al., 2013). Ecosystems assessed as threatened under this criterion should motivate government authorities to respond by (a) improving the management of species for agriculture, fish farming, and forestry production, (b) developing management and control of invasive species, (c) supporting initiatives for restoration of degraded ecosystems, and (d) implementing monitoring programs for environmental health and transmission of pathogens in wildlife and flora (Figure 1; Table 1). For example, the introduction of species such as bees for commercial purposes has altered pollination functions and community stability, induced virulent diseases, and suppressed plant reproduction success (Vanbergen, Espíndola, & Aizen, 2018). In the United States, the National Wild Pig Task Force, established as a part of the National Feral Swine Damage Management Program, is accomplishing significant advances on control of invasive wild pigs in North American natural ecosystems (Beasley, Ditchhoff, Mayer, Smith, & Vercauteren, 2018). Similarly, in Mercury Islands (New Zealand), control and restoration programs eradicated introduced rats reducing predation on seabirds and thereby promoting return of nitrogen to multiple trophic levels (Sinclair et al., 2018). Conversely, policies to reintroduce predators have reestablished the trophic webs in the Serengeti savannas (Tanzania; Sinclair et al., 2018).

3.5 | Quantitative analysis of the risk of collapse (E)

This criterion requires an estimate of the probability of ecosystem collapse based on simulation models parameterized by ecological data (Keith et al., 2013). Unlike other criteria, these models enable exploration of alternative policy and management scenarios to identify strategies likely to produce the greatest reduction in risks of ecosystem collapse. This informs allocation of resources to the most effective instruments for risk reduction. For example, scenario analyses showed that policy instruments addressing climate mitigation and adaptation are likely to reduce risks to the Mesoamerican Reef over the next 50 years more than other measures (Bland et al., 2017).

Preparing for application of criterion E also helps to map an agenda for long-term research and monitoring that is essential for reliable predictive modeling to inform ecosystem management. The required data may come from a variety of sources. Citizen science projects monitor biological and chemical trends in temperate still water lakes from Australia, Canada, the United States, UK, Netherlands, and France (Thornhill, Chautard, & Loiselle, 2018). Google Earth Engine platforms supported annual monitoring of the U.S. rangelands from 1984 to 2017 (Jones et al., 2018). Data from both examples support not only the assessment of criterion E and its role in informing strategic management decisions but also improve data quality and quantity for the assessment of all other Red List criteria.

4 | FRAMEWORK FOR INCORPORATING RLE INTO PUBLIC POLICY

The same ecosystem can often be threatened by multiple factors, exhibiting different symptoms (reduction of the distribution, alteration of processes, etc.) and thus trigger multiple RLE criteria. Such cases may require multiple policy instruments (an “instrument mix,” Ring & Schröter-Schlaack, 2011), being applied in different dimensions to ensure ecosystem conservation (Rogge & Reichardt, 2016; Schuster et al., 2017). These dimensions correspond to (a) policy fields (land
FIGURE 2  Suggested framework for the inclusion of RLE in the policy process, based on Dovers and Hezri (2010) and Rogge and Reichardt (2016). The figure shows the policy process based on a RLE assessment of a hypothetical ecosystem. Black lines represent the assessed RLE criteria; gray lines represent the non-assessed ones and the final status associated with each threat (column under RLE). The numbers represent the policy instruments listed in Table 1 and Figure 1; the colors refer to the threat status, according to the IUCN protocol. The development and prioritization for the policy implementation is based on those instruments related to threat status. Finally, the policy process has an impact on the different policy dimensions and should originate a new iteration of the process. E criterion was not considered in this example.

use planning, climate change, science, and industrial), (b) governance scales (country, region, and district), (c) geography, and (d) time. Different criteria may classify the same ecosystem in different categories of risk. This makes it possible to prioritize the actions within the policy strategy (goals and plans), aiming to tackle the causes responsible for the greatest risks, as identified by the criterion returning the highest category. In this vein, the threat status returned by each criterion could help to define the strategy in time and space, and thus the necessary instruments to reduce risks. Additionally, the spatial extent of the ecosystems could be useful to inform the governance scale at which these instruments should be applied.

Figure 2 presents a framework for integrating RLE into the policy development process. We illustrate this with a hypothetical example, in which criteria (a), (b), (c), and (d) were applied to assess one ecosystem: (a) land use change (in A and B criteria), (b) wildfires (in A and B criteria), (c) climate change (only in C criterion), (d) water exploitation (only in C criterion), and (e) biological invasions (only in D criterion). The rest of the criteria were not applied and remained as deficient data (DD) (Figure 2). In the example, the RLE shows that the ecosystem was classified as Critically Endangered (CR), Endangered (EN), or Vulnerable (VU), depending on the criterion and potential threat (Figure 2). The policy strategy should be selected and implemented by considering the ecosystem status, aiming to quickly stop or decrease the specific threat. In this case, the attention should be focused first on the regulation of land use change (the threat generating CR status), by implementing policy instruments related to this field (instruments 1–4 in Table 1). The next priority is for policies that reduce wildfires and water exploitation, which generate EN threat status (instruments 5 and 7 in Table 1). Finally, related to C criterion, threat by climate change should motivate the implementation of climate change contingency and adaptation plans (instrument 13 in Table 1). These policy instruments should be applied considering each dimension mentioned above to ensure coherence and consistency (McLean Hilker, 2004). After their application, it is important to learn and adapt them depending on how they have influenced changes in the threat status of the ecosystems (Figure 2). Implementing policy instruments for near threat and least concern status is less urgent in comparison with the endangered statuses (CR, EN, and VU); however, they could be implemented as a preventive strategy. Finally, the policy instruments choice and implementation strategy are also influenced by political feasibility and socioeconomic context of each country and territory.

The RLE method therefore supports land-use planning decisions by highlighting where in the landscape/seascape particular spatially explicit policy instruments (corrective or preventive) need to be applied to most benefit the reduction of risks (Keith, 2015). The integration of the RLE in the policy process and the engagement of different stakeholders will likely benefit in jurisdictions where Red Lists of Species are already established conservation tools (Bland et al., 2017; Keith et al., 2015). This benefits the credibility and comprehensiveness of the new instruments within the specific
5 | CONCLUSIONS

We identified 20 policy instruments relevant to ecosystem conservation management, and showed how Red List assessments of ecosystems could inform their selection and application within the policy process. We recommend that governments, nongovernment organizations, industries, practitioners, and research entities stimulate the development of national and local RLE, as well as their application to resource use and development decisions through conservation-focused public policies and industry development policies. The RLE is not limited only to traditional conservation topics, such as the design and evaluation of PA’s, and prioritization of conservation sites, but also has great potential in the design of land-use and zoning plans, ecological restoration strategies, as well as macroeconomic policy (e.g., through investment and taxation strategies). The ideas and examples detailed here may be adapted to the sociocultural, economic, and political contexts of each country, thereby promoting the effectiveness of public policies for the conservation of biodiversity. We hope that this article opens discussion for new applications of RLE in public policy.

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ORCID

Alberto J. Alaniz https://orcid.org/0000-0003-4878-8848

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