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POLICY BRIEF
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# Riparian Zones—From Policy Neglected to Policy Integrated

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1. Riparian zones are vital areas of interaction between land and rivers and are often degraded by several pressures such as urbanisation, intensive agriculture and river engineering works. 2. This policy brief provides five key policy messages and recommendations to be considered by policy-makers, scientists, managers, and stakeholders to enhance riparian zone management. 3. Adopting an integrated socio-economic and environmentally dynamic view will ensure the sustainable management of riparian zones. 4. In light of climate change, it is critically important to conserve and/or restore the ecological integrity of riparian zones. 5. European Union Directives and national-scale legislation and regulations need updating to ensure coordinated implementation of riparian zone-related policies. 6. Stakeholder knowledge exchange, policy co-creation and adaptive management are key to enhancing riparian zone functions.

**Keywords: freshwater resources, climate change, biodiversity conservation, ecosystem services, knowledge co-creation, adaptive management**

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## INTRODUCTION

Riparian zones are semi-terrestrial areas adjacent to rivers that influence and are influenced by freshwater dynamics. They include riverbanks and floodplains and are vital areas of interaction between land and water (Naiman & Decamps, 1997). They can sustain high levels of biodiversity and provide a large array of ecosystem services (Riis et al., 2020). Despite their scientifically recognised importance for human well-being, degradation of riparian zones is common and in some areas is even increasing (Janssen et al., 2020). Indeed, many aspects of riparian zone management are being driven by the development of human activities rather than by the maintenance of their ecological functions and associated benefits. Even when "high level" policy and legislative measures are in place to solve problems related to ecosystem function (e.g. European Union Green Deal, (EC, 2019), UN Decade on Ecosystem Restoration (UN, 2019)), there is little or no explicit mention of riparian zones. Therefore, explicit recognition and sustainable management are urgently needed to conserve and restore key riparian zone functions and services for current and future generations.

Riparian zones are recognized as vital areas for nature and humans, but their degradation tends to increase as there is no coherent policy, which would guide sustainable management efforts. This policy brief aims to support European and national policy-makers, riparian zone managers, scientists and other stakeholders by clarifying the key priorities and actions to be considered for effective policy development and management of riparian zones. We refer to three concepts that relate to riparian zone management: degradation (e.g. loss of socio-ecological functions), restoration (e.g. recovery from degradation), and conservation (e.g. protection and sustainable management). We outline five key policy recommendations to enhance riparian zone management related to 1) the need for an integrated socio-economic and environmentally dynamic view of the riparian zones, 2) updating the EU Directives and national legislations where riparian zones are explicitly recognized as separate critical assets, followed by 3) the need for effective coordination among policies and 4) implementing adaptive management. Finally, we recommend that 5) policy needs to be co-created with fostered knowledge transfer among scientists, managers and policy-makers. These five policy recommendations which are organised in individual sections emerged from a consultation process with managers and scientists throughout Europe who recognized and discussed the issues and potential solutions related to riparian zone management (**Figure 1**, for further details on consultatiuon methodology see **Supplementary Material**).

## Adopting an Integrated Socio-Economic and Environmentally Dynamic View

Closer attention to the sustainable management of riparian zones is urgently needed, because they are among the world's most degraded ecosystems (Tockner and Stanford, 2002). Although riparian zones are relatively small areas, they provide a disproportionately large number of benefits to ecosystems and humanity (Gonzalez et al., 2017).

Degradation of riparian zones often begins with impacts on the riparian vegetation in the form of forest clearing. For example, in cities, which are often developed along riverbanks and floodplains, paved and heavily managed forest-free riparian zones are now common. Moreover, because riparian zones are at the water-terrestrial interface, they are impacted by the combined pressures and stressors related to intensifying agriculture, population growth, urbanisation, river engineering works, as well as biological invasions (**Table 1**). Degradation is expected to increase as a result of continued deforestation (Olsson et al., 2019) and river engineering (Jiménez Cisneros et al., 2014). This is likely to have severe impacts on biodiversity and human well-being, as hydrogeomorphically dynamic riparian zones provide many ecosystem services to people including wood, water storage, drinking water, erosion control, flood

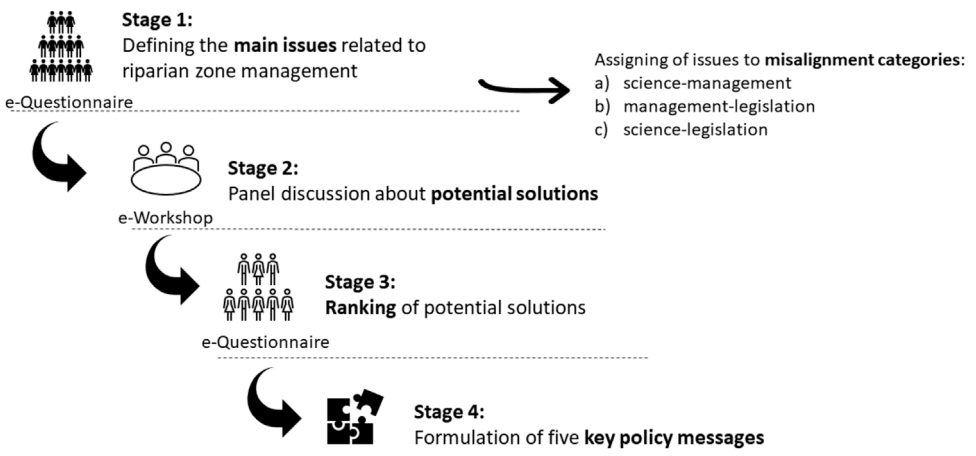


**FIGURE 1 |** The study design approach from which five key policy messages emerged.

**TABLE 1 |** Riparian zone management drivers in relation to knowledge and responsible policy. The below symbols indicate the spectrum of degree and directionality (++, +, -, --) for how each identified driver contributes to three concepts of riparian zone management: conservation, degradation, and restoration (e.g. international funding, there is a range of modest positive and negative incentives for conservation, positive incentives for degradation, and very positive incentives for restoration). Drivers belong to three different knowledge bases: policy, management and science. Key interpretations include that, first, especially policy drivers might show a spectrum of contribution levels. Second, managing responsibilities of drivers with a spectrum of contribution levels are usually scattered across different authorities, which is a clear indication that policy co-creation is needed. Third, several natural sciences and management related drivers with a direct impact on human well-being are listed in positive contribution to conservation. Policy related drivers, however, often do not contribute enough to conservation and thus sustainable human well-being.

| No | Knowledge Base | Driver | Conservation (Sustainable Management) | Degradation | Restoration | Responsible Policy |
|---|---|---|---|---|---|---|
| 1 | Policy | International funding | –/+ | + | ++ | Nature conservation/River basin management/Energy policy |
| 2 | Policy | Riparian vegetation management costs | –/++ | + | -- (in order to achieve objectives) | Flood protection/River basin management/Agricultural policy (e.g. CAP)/Forestry management |
| 3 | Policy | Urbanisation | — | ++ | –/+ | Spatial planning/Energy policy |
| 4 | Policy | Increase in economical value of the land | –/+ | ++ | + | Spatial planning |
| 5 | Policy | Recreation | ++ | –/+ | + | Human health |
| 6 | Policy | Agricultural intensification | - | + | — | Agricultural policy (e.g. CAP) |
| 7 | Policy | Forestry-logging | + | –/+ | + | Agricultural policy (e.g. CAP)/Forestry management (e.g. Forestry strategy) |
| 8 | Management | Experience with sustainable management | ++ | — | - (often absent)/+ | Flood protection/River basin management/Agricultural policy (e.g. CAP) |
| 9 | Management | Past management practices | ++ | — | — | Flood protection/River basin management/Agricultural policy (e.g. CAP) |
| 10 | Management | Culture of living with riparian zones | ++ | — | — | none identified |
| 11 | Management | Population growth and migration | - (needed additional measures) | ++ | — | Spatial planning/Energy policy |
| 12 | Management | Flood protection engineering works | — | ++ | - (often partially needed) | Flood protection/River basin management |
| 13 | Management | Vegetation development | ++ (economic value) | -- (needed activities to remove vegetation) | + (planting of trees) | River basin management/Forestry management |
| 14 | Management/ Science | Freshwater for food and drinking | ++ | -- (needed activities to treat water) | + | Water resources management/Food and feed law |
| 15 | Science | Gravity drainage | ++ | — | + | none identified |
| 16 | Science | Biofiltration | ++ | — | + | Nature conservation/Water resources management/Food and feed law |
| 17 | Science | Water storage | ++ | — | + | Flood protection/River basin management/Agricultural policy (e.g. CAP) |
| 18 | Science | Sediment deposition | ++ | — | + | Flood protection/River basin management/Agricultural policy (e.g. CAP) |
| 19 | Science | Nutrient cycling-soil quality | ++ | — | + | Agricultural policy (e.g. CAP) |
| 20 | Science | Erosion control | ++ | — | + | Flood protection/River basin management/Agricultural policy (e.g. CAP) |
| 21 | Science | Biodiversity | ++ | — | + | Nature conservation |
| 22 | Science | Heatwaves effects | ++ | — | + | Human health |
| 23 | Science | Buffer of the noise | + | — | + | Human health |
| 24 | Science | Visual contrast | + | — | + | Human health |
| 25 | Science | Awareness | –/+ | — | ++ | none identified |
| 26 | Science/Policy | Lobbies—pressures on policy-makers | — | ++ | –/+ | none identified |
| 27 | Science | Biodiversity—aesthetic value | + (often not recognised) | –/+ | + | Human health |

*CAP, Common Agricultural Policy.*

management, recreation and the reduction of heatwave effects (Riis et al., 2020). These ecosystem services are strongly related to healthy freshwater ecosystems, which play a fundamental ecological role, e.g., nutrient and water cycling. Extreme weather events resulting in severe flooding are becoming more and more frequent while the number of people living in riparian

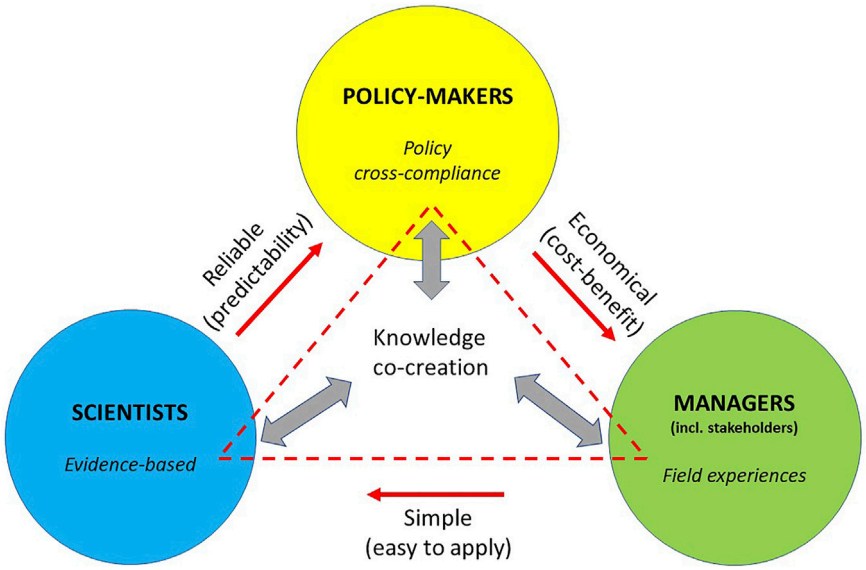


**FIGURE 2 |** "Knowledge co-creation triangle" for enhanced riparian zone management. The Figure highlights, first, that all three groups (scientists, policy-makers and managers) create knowledge and contribute to the sustainable management of riparian zones. Second, scientists contribute with the evidence-based approach, policy-makers assure cross-compliance among all relevant policies related to riparian zones and managers provide field experiences supported by the local knowledge. Third, red arrows indicate addressing direction of scientists, policy-makers and managers about the approaches used in riparian zone management that should be reliable, economical and simple.

areas is increasing (Tellman et al., 2021). So, unless riparian zone restoration, protection and sustainable management of still functioning riparian zones intensifies, more regions and people will be at imminent risk of floods.

It is clear that riparian zones are not recognized as critical assets in their own right and their sustainable management is not sufficiently supported at all levels of decision making, e.g. strategic and operational and among all stakeholders interested in riparian zones. Several natural science and management related drivers, e.g. water storage, sediment deposition, and a culture of living with riparian zones, are recognised as positive contributions to sustainable management (**Table 1**). Policy related drivers, e.g. international funding, however, often do not contribute enough to conservation and thus sustainable human well-being, although more and more support restoration efforts. Restoration of riparian ecosystems, however, is a long-term process, especially where the degradation of complex ecosystems needs to be reversed. The cornerstone of sustainable management of riparian areas is the desire to consider them as living environments where ecological and social processes are inexorably linked. It is a challenge because managing responsibilities for the various drivers, within spectra of contribution levels, are scattered across different authorities e.g. nature conservation, energy, river basin management and, agriculture, which is a clear indication that policy coordination is needed. Moreover, policy-makers need to be aware that actions in riparian zones are interconnected, affecting upstream and downstream ecosystems, as well as people who live and work beyond the immediate sites of degradation (Olsson et al., 2019). The changes in the riparian zone land use upstream, for example, impact large river fish and benthic invertebrate assemblages downstream (Knehtl et al., 2021).

## Updating the EU Directives and National Legislations

The riparian zone, in spite of its critical role for freshwater ecosystems, fails to be integrated clearly in many European policies. For example, riparian ecosystems are not explicitly mentioned by the EU Water Framework Directive (WFD) (EC, 2000) as a quality element and continue to degrade, despite two cycles of River Basin Management Plans (González del Tánago et al., 2021). Furthermore, the recognised role of riparian zones in flood mitigation and improved water quality protection is not considered commensurate with the services provided in the EU Floods Directive (EC, 2007), the EU Sustainable Use of Pesticides Directive (EC, 2009), and in many other related national level regulations. The recent EU Common Agricultural Policy (CAP) (EC, 2021) accepted in 2021 was revised to incorporate the sustainable ambitions of the European Green Deal. However, the means by which farmers and landowners receive reward or compensation for sustainably managing riparian zones remains unclear (Englund et al., 2021). An additional obstacle to sustainable management is the legal definition of riparian zone as an area of fixed width (Dufour et al., 2019), dismissing the complexity and dynamics of riparian ecosystems. There are opportunities to learn from countries where legislation includes a dynamic definition. For example, "Dominio Público

Hidráulico" in Spain, which is defined by the ordinary flood, considers a variable riparian zone width based on a specific return period of flooding. Dynamic definitions alone, however, do not assure sustainable management of riparian zones, which reflects also in the current poor riparian zone conditions in Spain.

The current political context, at both global (e.g. UN Decade on Ecosystem Restoration (UN, 2019)) and European levels (e.g. EU Green Deal (EC, 2019), with Biodiversity Strategy for 2030, and the upcoming Law on Restoration), presents an opportunity to review pending issues on river management that include riparian zones. EU directives and other legislations, which consistently with the scientific evidence explicitly recognize riparian vegetation as a major supporting element of functioning fluvial ecosystems, would crucially contribute to achieving their objectives. There is thus a need to recognize riparian zone sustainable management as a key element of successful green initiatives and all riparian zone-related policies.

## Effective Coordination Among Policies

There is no specific policy which would guide sustainable management of riparian zones thus effective riparian zone policy implementation needs to rely on good coordination. In large or overlapping organisations there is a risk that different sectors establish policies in isolation, leaving gaps or creating conflicts (Jordan and Schout, 2006). Lack of coordination among administrations has been already identified as a barrier to natural resource management (Cortina-Segarra et al., 2021). It is important that there are processes of coordination to identify gaps and resolve conflicts as soon as they are recognised (Alexander, 1995).

In the European Union policies are supposed to be coordinated. However, there is a particular problem of policy gaps and conflicts related to the management of riparian zones. First, as mentioned before, the riparian zone fails to be integrated clearly in key European environmental policies. Only the Habitats Directive clearly indicates the importance of riparian zones, but lacks connections with other regulations to support its goals (González et al., 2017). Second, even when riparian zones are indirectly considered as in the WFD, implementation at the national level is usually difficult due to conflict of policy interests. Territoriality adds further complexity to policy coordination (Dudek, 2005), with European level policies being fragmented at the national level. For example, the WFD tends to be fragmented into national policies related to flood and water quality management and sustainability management objectives of riparian zones, conflicts with the Renewable Energy Directive regarding hydropower (Jansson et al., 2000). Disappointing case studies that exemplify the consequences of gaps, conflicts and fragmentation can be found throughout Europe (Gumiero et al., 2013).

Based on current scientific knowledge, it is clear that the ecological, functions of riparian zones affect several policy sectors e.g., agriculture, river basin management and nature conservation. There is a need to articulate the benefits of sustainable riparian zone management in different policies, and to integrate conservation and restoration activities on the operational stage. This can best be done by involving and training stakeholders from different policy sectors and national authorities in the development of policies on a regular basis as an element of co-creation, and by seeking to learn from experiences in the field, ideally using data and information consolidated from adaptive management processes.

# IMPLEMENTING ADAPTIVE MANAGEMENT

Riparian zones are highly dynamic and complex systems, which makes prediction of system behaviour difficult and thus leads to uncertainty in management. Such uncertainty is often exacerbated by a scattering of management responsibilities across different authorities which leads to management fragmentation. Fragmentation leads to uncoordinated actions, making it difficult to assign responsibility to damaging entities. To overcome this uncertainty and address management fragmentation, the use of adaptive management in riparian contexts has often been advocated (Arnold et al., 2012) but less frequently implemented. Adaptive management builds on a willingness to collaborate among actors such as managers, stakeholders, and scientists and relies on three elements: 1) a clear definition of the system's development model and management objectives; 2) recurring monitoring of the system to check whether the development model is working and the path to the objectives is being attained; and 3) regular evaluation and revision of model, strategy and objectives (Haney and Power, 1996). Recently, a dynamic adaptive policy pathways approach was introduced, in which management strategies are changed based on their effectiveness in relation to set objectives (Kwadijk et al., 2010). Common objectives, however, are needed first.

In the context of riparian zones, appropriate monitoring is often one of the most overlooked elements. However, these are very dynamic socio-ecological systems that require adaptation of the management plan to regularly check that all issues (including emerging issues) are included in the definition of objectives. Moreover, monitoring and assessment are needed to adjust management practices to ensure consistency with management objectives. The management of riparian zones is of interest to many sectors such as river basin management, energy sector and nature conservation and might have conflicting objectives. Cross-policy implementation activities with a common riparian zone adaptive management plan would overcome this obstacle.

## Policy Co-creation With Fostered Knowledge Transfer

There are gaps between contemporary scientific knowledge and decision-making, and this has resulted in several calls for closer integration of science with policy making (Sutherland et al., 2013). As a result, a scientific, evidence-based approach is becoming more and more common in environmental policy (National Research Council, 2005). However, applying science to environmental policies remains a challenge in achieving effective environmental management for three key reasons, as follows.

First, there is a vast and scattered array of relevant scientific research available to inform policy, and this is especially true in

the field of riparian zone research (Dufour et al., 2019). It is challenging and potentially overwhelming for policy makers to decide on which research outcomes to prioritise and how to integrate scientific results from different fields. At the local level "policy-pull" models are often used (Dilling and Lemos, 2011). These approaches often depend on the ability of researchers to promote the application of their research in policy development and can be based on unsound or outdated practices or even in ideologies. They are, however, not appropriate for natural resources management, which refers to the sustainable utilisation of major natural resources and should be evidence-based. Thus, to enhance riparian zone management there is a need for a common framework to organise and disseminate findings across scientific disciplines that use different concepts and languages to describe and explain complex social-ecological systems and to accumulate isolated knowledge (Ostrom, 2009).

Second, policy makers are often pressured by varied interest groups, with a partial view on the use of a particular riparian zone e.g., as a potential area for urbanisation, agriculture, intensive logging or recreation. Key to addressing these challenges is the use of the policy-science interface co-creation model (**Figure 2**), which allows for the exchange and co-creation of knowledge with the aim of enriching decision-making (Van den Hove, 2007). The knowledge co-creation concept enables the use of a scientific, evidence-based approach with organised findings across scientific disciplines (Mauser et al., 2013). This should be based on rigorously established, objective evidence and results in methodologies that are applicable by managers.

Third, management experiences and local knowledge of riparian zone management should be considered (Olsson et al., 2019). Although a proposed management practice in the riparian zone might vary depending on the local context, basic knowledge needs to be progressively transferred among all involved to establish sufficient shared understanding of the proposed solutions and to understand social values, vulnerabilities and possible risks (Haasnoot et al., 2021). In short, there are both training issues for technicians and elected officials and issues in taking local stakeholders into account in scientific diagnostic tools.

In particular, all those involved in policy co-creation need to be motivated throughout the whole knowledge exchange process. Understanding consequences of loss of ecosystem services in degraded riparian zones on the one hand and raising awareness of conserved services on the other, might encourage citizens to actively participate in riparian zone policy development and implementation. Achieving this might be a long and challenging process, but it can start with the simple step of highlighting the multiple benefits that riparian zones provide. In the end, only implementation of enhanced riparian zone management practises will enable the achievement of both resilient riparian ecosystems and sustainable human well-being.

## CONCLUSION

Resilient riparian zones are crucial for human well-being but many have been severely degraded with conditions likely worsening in the near future. Consequently, there is a need for enhanced riparian zone management, including restoration of degraded zones and conservation of existing functional riparian ecosystems. However, currently, there is no specific policy which addresses riparian ecosystems to guide sustainable management efforts and this topic has fallen into a gap between the existing policies. Despite many restoration efforts, riparian ecosystems are under threat due to unsustainable activities related to urbanisation, population growth, flow regulation, energy and agricultural demands. Thus, there is a need for an update of EU Directives and national legislations which will assure coordinated implementation of riparian zone-related policies. Coordinated and integrated management needs to be based on adaptive and evidence-based science and long-term monitoring, which will enable managers to check whether management models are working and if the path to achieving objectives is being attained. Knowledge exchange is a prerequisite to enhanced management of riparian zones. Co-creation of policies will contribute to riparian zone sustainability and result in resilient ecosystems. This call is well aligned with the EU Green Deal and the UN Decade on Ecosystem Restoration vision because of the clear and urgent needs to mitigate climate change, halt biodiversity loss and improve human well-being.

## ACTIONABLE RECOMMENDATIONS

In developing and implementing the policy for enhanced riparian zone management, we provide the following five key messages with actionable recommendations along with a brief explanation based on available and relevant evidence. Some of the recommendations are implementable in the short term as they only depend on the "political will", whereas some others e.g. EU policy changes are more long-term as the process is related to the policy revision cycle.

1. Adopt an integrated socio-economic and environmentally dynamic view on riparian zones.

Riparian zones are not recognized as separate critical assets and their sustainable management is not sufficiently supported at all levels of decision making and among all stakeholders. Promoting an integrated socio-economic and environmentally dynamic view will ensure the sustainable management of riparian zones.

2. Update the EU Directives and national legislations.

The riparian zone, in spite of its critical role for freshwater ecosystems, fails to be integrated clearly in many European policies. European Union Directives and national-scale legislation and regulations should be updated based on scientific evidence to ensure that riparian zones are better integrated into water resources management and spatial planning.

3. Effectively coordinate all riparian zone related policies.

It is clear that the ecological functions of riparian zones affect several policy sectors. There is a risk that different sectors establish policies in isolation, leaving gaps or creating conflicts. There is a need to better articulate different policies through joint evaluations at both large strategic and local operational scales.

4. Implement adaptive management with an appropriate monitoring and assessment.

The complexity of the riparian zone makes prediction of system behaviour difficult and thus leads to the need for incorporating uncertainty in management. For this reason, monitoring and assessment is needed to adjust management practices to ensure consistency with management objectives.

5. Implement policy co-creation approach and foster knowledge transfer.

There are gaps between contemporary scientific knowledge and decision-making. Key to addressing these challenges is the use of the policy-science interface co-creation model, which allows for the exchange and co-creation of knowledge with the aim of enriching decision-making. Co-creation of policies will contribute to riparian zone sustainability and result in both resilient riparian ecosystems and sustainable human well-being.

## AUTHOR CONTRIBUTIONS

GU led the preparation of this manuscript, GU, EP: Conceptualization, data collection, formal analysis, and methodology, writing the original manuscript, editing. PR-G, RP: Writing the original manuscript and editing. SD: Reviewed the paper, editing and data collection, DS: Reviewed the paper and editing. All authors (GU, EP, PR-G, RP, DS, MHA, AA, DB, MC-L, SDL, RE, VG-G, IGM, MGT, YSG, BG, SH, GH, JJ, PJ, RJ, MK-Q, TK, SL, RMR, ZM, EP, MPU, EPn, TR, JS, MS, TZ, SD) contributed to data collection and/or discussion and writing this manuscript.

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## SUPPLEMENTARY MATERIAL

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