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EMERGING KEY MESSAGES FOR THE STATE OF KNOWLEDGE REVIEW ON THE INTERLINKAGES BETWEEN BIODIVERSITY AND HUMAN HEALTH

Note by the Executive Secretary

1. The Executive Secretary is circulating herewith, for the information of participants in the eighteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, the emerging key messages associated with the *State of Knowledge Review on the Interlinkages between Biodiversity and Human Health*.[1] The document is being made available for the purpose of peer-review.

2. This document contains a preliminary draft of emerging key messages which are subject to further review in the *State of Knowledge Review on the Interlinkages between Biodiversity and Human Health*. A final version of the key messages will contains cross-references with the main text which itself will be fully referenced. The State of Knowledge Review is being prepared by a consortium of partners including the Secretariat of the Convention on Biological Diversity, the World Health Organization, Ecohealth Alliance, Bioversity International, DIVERSITAS and Wildlife Conservation Society, HEAL.

3. The present document is being made available for the purpose of peer-review. Until official publication, the data, material and messages contained in this document may not be republished, displayed, distributed, or transmitted in any manner, nor may the material, or portion thereof, be copied or posted on any other website or network or otherwise distributed, quoted or cited. The document, as well as review template, can be accessed from http://www.cbd.int/en/health/what-s-new. The peer-review is open until 10 July 2014. Comments should be sent by e-mail to secretariat@cbd.int or by fax to +1 514 288 6588.

4. Further information on the *State of Knowledge Review on the Interlinkages between Biodiversity and Human Health*, and other items of cooperation with other conventions has been made available as document UNEP/CBD/SBSTTA/18/17. The complete State of Knowledge Review is expected to be launched at the twelfth meeting of the Conference of the Parties.

* UNEP/CBD/SBSTTA/18/1.

[1] UNEP/CBD/SBSTTA/18/17, section II.

EMERGING KEY MESSAGES[i]

PART I

Introduction

1. **As defined by the World Health Organization, “health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”.** As a ubiquitous concern for all populations, health status has important social, economic, behavioral and environmental determinants and wide-ranging impacts. Typically health has been viewed largely in a human-only context. However, there is increasing recognition of the broader health concept that encompasses other species, our ecosystems and the integral ecological underpinnings of many drivers or protectors of health risks.

2. **Biological diversity (biodiversity) is “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”** This definition of the Convention on Biological Diversity (Article 2) recognizes levels of variability within species, among species, and within and among ecosystems, and reflects levels and complexities of biotic and abiotic interactions. Genetic diversity, for example, is an important source of genetic materials for human use, which have different nutritional and medicinal or health benefits. The attributes and interactions of biotic and abiotic components determine ecosystem processes and their properties and they influence changes in each of the latter over space and time. The effective management of ecosystems as part of comprehensive public health measures requires that these various complex linkages and interactions be identified and understood.

3. **Biodiversity underpins ecosystem services that are essential to human health and well-being.** Services provided by ecosystems include food which underpins nutrition and food security, clean air and both the quantity and quality of fresh water, medicines, spiritual and cultural values, climate regulation, pest and disease regulation, and disaster risk reduction, including as these contribute to local livelihoods, health and economic development. Protecting biodiversity and natural landscapes can benefit human health by protecting the sources of existing and future medicinal resources.

4. **Anthropogenic drivers of biodiversity loss are hindering the capacity of ecosystems to provide essential services.** The continued decline of biodiversity, including loss of or degradation of ecosystems, is reducing the ability of ecosystems to provide essential life-sustaining services and in many cases is contributing to increased problems for health and well-being.

5. **Traditional measures of health are often too limited in focus to adequately encompass all the health benefits of conservation.** While the definition of health adopted by the World Health Organization in 1946 encompasses "physical, mental and social well-being as well as the absence of disease and infirmity", traditional measures of health tend to have a more narrow focus on morbidity, mortality and disability, but fail to capture the full breadth of complex linkages at the biodiversity-health nexus or health benefits associated with biodiversity conservation. Summary measures such as disability adjusted life years (DALYs) and burden of disease mainly aggregate these three into one metric. All are important and useful, reflecting health goals to reduce these negative outcomes. However, traditional health measures often fall short of considering the multitude of factors promoting or

determining individual and population health under WHO's broader definition. For this reason, evidence of the contribution of biodiversity conservation to human health through ecosystem functioning also falls short. For the latter to be more adequately credited, alternative metrics defining health are needed.

6. **Ecosystem restoration is often a viable and cost-effective solution to human health and well-being problems and provides co-benefits in terms of improved biodiversity conservation outcomes.** In many cases, the objectives of human health and biodiversity conservation are mutually supporting. Ecosystem restoration measures can additionally contribute to the implementation of the Strategic Plan for Biodiversity 2011-2020 and its Aichi Targets, in particular Aichi Target 14.

7. **Biodiversity, or ecosystem, based solutions need to be further mainstreamed into human health policies and programmes as do human health considerations into biodiversity conservation programmes.** Options need to be tailored to specific needs and circumstances but often win-win solutions are available. This requires improved coordination across various interest groups.

Equity and social dimension of health and biodiversity

8. **Human population health is determined, to a large extent, by social, economic and environmental factors.** These determinants of health reflect the social, economic, and behavioural aspects of the human condition as critical components of all aspects of biodiversity, such as biodiversity loss and gains, ecosystem services, and biodiversity policies.

9. **Equity issues are not only important to different groups within a country, but also in relation to different vulnerabilities among countries.** Developing countries are often more reliant on biodiversity and ecosystem services than developed countries. For example, over one billion people, mainly in developing countries, rely on fisheries as their primary source of animal protein.

10. **Disproportionate impacts of biodiversity loss including on health, are driven by social determinants (such as poverty, gender, sex, age, and rural versus urban areas).** Vulnerable people and groups most reliant on biodiversity and ecosystem services (such as women and the poor), especially on provisioning services such as timber, water and food, are generally more vulnerable to biodiversity loss and less covered by social protection mechanisms (e.g. health insurance).

11. A social justice perspective is needed to address the various equity dimensions in the biodiversity and health dynamic. Many social issues arise among vulnerable populations, specifically populations who are dependent on biodiversity and ecosystem services (forest dwellers, indigenous populations etc.). Vulnerability and adaptation assessments are needed and should be adapted to serve these populations.

12. **Different gendered roles in relation to biodiversity conservation impact health.** Access to, use, and management of biodiversity has differential gender health impacts shaped by respective cultural values and norms which in turn determine roles, responsibilities, obligations, benefits and rights. In addition to the lack of political will and frequently weak institutional capacity and legal frameworks that inadequately reflect differential gender roles, there is a lack of gender disaggregated data on biodiversity access, use & control and resulting differential health impacts by gender.

Drivers of disease, ecosystem degradation and biodiversity loss

13. **Demographic change, anthropogenic activity and large-scale social and economic processes contribute to biodiversity loss with potentially negative repercussions on public health.** Biodiversity is a key environmental determinant of human health and changes in biodiversity (including losses and gains) are often the result of anthropogenic influences. Ill health, disease emergence and biodiversity loss often share common drivers. Demographic change and resulting changes in production and consumption patterns, and anthropogenic drivers such as land use change, overexploitation of resources, human-induced climate change, habitat loss, and conflict over natural resources often threaten biodiversity, ecosystems and related ecosystem services, compounding threats to public health. Social change and development biases (such as urbanization, poverty and equity) also influence these drivers of change. Macro-economic policies and structures, and public policies that provide perverse incentives or fail to incorporate the value of biodiversity often compound the dual threat to biodiversity and public health.

Integrating Biodiversity And Human Health: Approaches, Frameworks And Knowledge Gaps

14. **The social and natural sciences are important contributors to research and policy making in biodiversity and health, including multidisciplinary approaches such as the Ecosystem Approach, Ecohealth and OneHealth.** Multi-disciplinary research and approaches can provide valuable insights on the drivers of disease emergence and spread, contribute to identifying previous patterns of disease risk and help predict future risks through the lens of social-ecological systems. Biodiversity and health challenges necessitate engagement of many stakeholders, including governments, civil society, and non-governmental and international organizations.

PART II- THEMATIC SECTIONS

WATER AND AIR QUALITY

Water quality

15. **Ecosystems provide clean water which underpins most aspects of human health.** All terrestrial and freshwater ecosystems play a role in underpinning the water cycle including regulating nutrient cycling and soil erosion. Many can also play a role in managing pollution. The water purification services provided by ecosystems therefore underpin water quality – a universal requirement to maintain human health. Freshwater ecosystems, such as rivers, lakes and wetlands, face disproportionately high levels of threats to biodiversity due largely to demands on water. Freshwater species have declined at a rate two-thirds greater than terrestrial and marine species in the preceding three decades.

16. **Impaired water quality results in significant social and economic costs.** Ecosystem degradation is a major cause of declines in water quality. Rectifying poor quality water through artificial means (such as water treatment plants) requires substantial investment and operational costs. Left untreated, poor quality water results in massive burdens on human health, with women, children, and the poor the most affected. Maintaining or restoring healthy ecosystems is a cost-effective and sustainable way to promote water quality while also benefitting biodiversity. Many protected areas are established primarily to protect water supplies for people.

17. **Water-related infrastructure has positive and negative impacts on biodiversity, livelihoods, and human health.** Altered waterways (e.g. dams, irrigation canals, urban drainage systems) can provide valuable benefits to human communities, but may be costly to build and maintain, and in some cases increase risks (e.g. flood risk from coastal wetlands degradation). They can also diminish native biodiversity and increase water-borne illnesses, such as malaria and schistosomiasis. An approach integrating benefits of both physical/built (hard) and natural (soft/ecosystem) infrastructure can provide more cost-effective and sustainable solutions.

Air quality

18. **Ecosystems may affect air quality with negative or positive implications and thereby affect human health.** Four main ways in which ecosystems affect air quality include: (1) *Deposition* – ecosystems directly remove air pollution, including through absorption or intake of gases through leaves, and through direct deposition of particulate matters on plant surfaces. Natural and man-made ecosystems have a direct influence on levels of airborne particulate matter, by removing particles, resuspension of particles trapped on leaf surfaces, and release of particles such as pollen. (2) *Change in meteorological patterns* – as ecosystems affect local temperature, precipitation, air flows etc., they also affect air quality and pollutant emissions. (3) *Emissions* – many ecosystems emit volatile organic carbons (VOCs) including terpenes and arenes. While VOCs from vegetation are sometimes considered as pollutants, many natural VOCs play a critical role in atmospheric chemistry and air quality regulation. Ecosystems also release pollen, sometimes associated with acute respiratory problems. Burning of vegetation is also associated with significant pollution emissions. (4) *Avoided emissions* – by altering climate and shading buildings, ecosystems in cities alter energy use and consequent emissions. In urban parks and forests reduce fine particulate air pollution has been demonstrated for both PM10 and PM2.5.

19. Air pollution control provides benefits for ecosystem functioning, biodiversity and associated ecosystem services, as well as for human health. Recent research indicates that global deaths directly or indirectly attributable to outdoor air pollution reached 7 million in 2012, making air pollution one of the most significant environmental health risks worldwide. Several respiratory illnesses caused or affected by air pollution, such as bronchial asthma and chronic obstructive pulmonary disease (COPD), are on the rise. Other diseases affected by air pollution include cardiovascular disease, immune disorders, various cancers, and disorders of the eye, ear, nose and throat. Premature deaths from non-communicable diseases attributed to exposure to household air pollution (including stroke, ischaemic heart disease, lung cancer and COPD) are estimated at 3.8 million annually. Air pollution also affects biodiversity by either acting as a fertilizer in some cases or causing damage to ecosystems. It has also been shown to reduce plant biodiversity and affect other ecosystem services, such as clean water and carbon storage.

20. **Components of biodiversity can be used as bioindicators of known human health stressors, as well as in air quality mapping, monitoring, and regulation.** Lichens are among the most widely utilized and well-developed indicators of air quality to date and are making headway as reliable indicators for air quality regulation. The shift in species is predictable and often correlates highly with deposition measures, making lichens an accurate, cost-effective tool for mapping and monitoring. Epiphytic lichens and moss are practical bioindicators for use near human populations because they grow on woody vegetation and are less controlled by landscaping. However, within highly polluted locales, lichen

communities may have very low diversity or be wiped out completely, depending on the mix of pollutants and local climate patterns affecting susceptibility. An additional limitation is that the link with epidemiological evidence is sometimes weak.

FOOD PRODUCTION AND NUTRITION

Agricultural biodiversity

21. **Agricultural biodiversity is a central feature of farming systems worldwide, contributing to a large proportion of global food production and to food security.** Not only does it encompass several species and genetic resources but also the many ways in which farmers can exploit biodiversity to produce and manage crops, land, water, insects and biota. s. Agricultural biodiversity includes habitats and species inside and outside farming systems that benefit agriculture and enhance ecosystem functions. For example it is a source of host plants for natural enemies and predators of agricultural pests. Recognizing and supporting the importance of small-scale producers (farmers, pastoralists, forest dwellers and fisher folk) as custodians of agricultural biodiversity and responsible for the bulk of global food production may therefore be import to support human health.

22. **Biodiversity in agricultural ecosystems contributes to agricultural productivity and sustainability, supports production, and provides pollination and pest control services, all of which can support good health.** Thus, biodiversity, agricultural production and human health can be mutually supportive. Agricultural biodiversity helps sustain the functions, structure and processes of agricultural ecosystems. Wider deployment of agricultural biodiversity will be essential to achieve a sustainable delivery of greater agricultural productivity and a more secure and healthy food supply. Diverse farming systems and landscapes can contribute to improved diversity of diet, better nutrition and greater health with additional benefits for human productivity and wellbeing. Diversity can also increase productivity of farming systems, make them generally more resilient to shocks and stresses, help maintain and increase soil fertility, and mitigate impacts of pests and diseases.

23. **Climate change and biodiversity loss pose threats to agricultural biodiversity, and increased efforts will be required to conserve the diversity of animals, plants and their wild relatives.** Changes in ecosystem equilibrium and loss of biodiversity as a result of land use change, increasing urbanization and climatic shocks, among others, result in shifts of species distribution, altered pest and disease occurrences and a reduction of pollinators for sufficient food diversity and occurrence, with consequences for human health. Land use change and intensive mono-crop and cash crop farming systems also have negative repercussions for the diversity and existence of wild food species in managed and unmanaged landscapes, reduce agricultural and food productivity, and contribute to malnutrition. Strengthening the agricultural biodiversity knowledge base and the facilitation of innovative research partnerships is essential to identify ways in which agricultural biodiversity can better contribute to global health and biodiversity challenges. Both *in situ* and *ex situ* conservation strategies and the improved use of genetic resources will be essential to meet changing production environments.

24. **Pollination is essential to both food and nutrition security, and it plays a critical role in the maintenance of wild plant communities as well as agricultural productivity.** Pollination services are reliant upon both domesticated and wild pollinator populations, and both may be affected by drivers of biodiversity loss and change, with unknown but potentially critical

consequences for the health and well-being of all people, including the poor and vulnerable. Agricultural productivity is dependent upon pollinator services, which affect approximately one third of global food supply. Global declines of pollinator species have critical implications for food security, agricultural productivity, and ecosystem functioning. Pollination does not only affect the overall quantity of foods such as fruits, seeds and nuts, but also the nutritional content, quality, and variety of foods available. Crop plants dependent on pollinator species have been found to contain most of the global availability of vitamins A, C and E and dietary lipids as well as an important proportion of minerals, calcium, fluoride, and iron. Accordingly, yield increase attributable to animal pollinated crops are essential to nutritional diversity and human health and their resulting decline can have significant consequences for both food and nutrition security as well as human health.

25. **Biodiversity has positive effects on the regulation of pests and disease.** The continuous use of synthetic pesticides can lead to serious environmental pollution (water, air and soil), affecting human health and causing the death of many other non-target organisms (animals, plants and fish), emphasizing the need for more sustainable forms of pest control. Pesticides are substances used to prevent, destroy, kill, control or mitigate pest problems. These can be either synthetic or of plant or animal origin. Although plant-derived forms are sometimes less effective than many synthetic pesticides, their acceptability increases as they are more environmentally benign, accessible for small-scale farmers, safer, lower-cost, and difficult to adulterate. Unsustainable harvesting of many of these resources, leading to loss in biodiversity, has been a great concern. Concerted efforts in conservation of genetic resources of pesticidal plants and animals through propagation, sustainable harvesting and use can contribute to increased agricultural productivity, sustainable livelihoods and environmental sustainability, justifying their inclusion in agricultural policies.

26. **Biological control methods such as integrated pest management (IPM) provide more sustainable alternatives to chemical pesticides which minimize unintended impacts of chemical pesticides on biodiversity and human health.** Integrative strategies such as Integrated Pest Management, which combines pest control methods to cause the least possible harm to people, property, and the environment, can often provide effective, cost-efficient and more sustainable pest control methods. Building capacity of farmers and local institutions in on-farm management strategies and efficient utilization of such measures, agricultural production could be increased. IPM systems give preference to biocontrol methods such as crop rotations, intercropping, and other methods aimed at disrupting pest cycles, using least toxic chemical pesticides only as a last resort and minimizing the impacts of chemical pesticides. IPM, which is compatible with each conventional, organic and genetically modified agriculture, will be mandatory for all agriculture in the EU starting in 2014. Biopesticides require further development to improve their effectiveness and production costs.

Nutrition

27. **Wildlife from aquatic and terrestrial ecosystems is critical to nutrition and to combatting the global burden of malnutrition.** Malnutrition is the single largest contributor to the global burden of disease and undernutrition, and micronutrient deficiencies disproportionately affect poor and vulnerable populations. Malnutrition accounts for roughly one third of the total burden of disease in poor countries. In addition to undernutrition (inadequate caloric intake), micronutrient deficiencies affect roughly 2 billion people globally and disproportionately impact children and pregnant women. Wildlife from

aquatic and terrestrial ecosystems is a critical source of calories and micronutrients like iron and zinc for more than a billion people, and conservation strategies to maintain robust populations of these animals are not only a critical biodiversity conservation priority, but would also pay significant public health dividends. With a disproportionate amount of human population growth in coastal areas and the decline of global fish stocks, these interactions between harvested wildlife and human health are also critically important in marine systems, and only expected to increase in importance.

28. **Variety-specific differences can can determine nutrient deficiencies versus nutrient adequacy in populations and individuals.** The scientific literature reports significant intraspecific differences in the nutrient content of most plant-source foods (i.e. among the different varieties or cultivars of a given species). Nutrient content differences in meat and milk among breeds of the same animal species have also been documented. The differences are statistically significant, and more importantly, nutritionally significant, with up to 1,000-fold differences.

29. **Knowledge on the compositional data of food sources (including underutilized, wild species and the majority of cultivated food species, varieties and breeds) is essential to promoting and expanding their use and, consequently, their health benefits.** Wild and cultivated food species contain essential nutrients, but information on the composition and consumption of these foods is limited and fragmented. The potential of indigenous wild and underutilized food sources, such as indigenous fruit trees (IFT), has largely remained untapped due to scant information on the nutritional and economic value of such foods. Information on nutrient content may also facilitate selection of priority species for domestication programs aiming at improving food and nutrition security and income generation. Developing and disseminating nutrient-sensitive processing techniques can further contribute to rural livelihoods through diversification of income generating activities and by extending the shelf-life and availability of wild food products for consumption during off-seasons.

30. **Well-managed agriculture and ecosystems, and the preservation of genetic diversity, are important to nutrition security.** Global agricultural production is theoretically able to feed the world's population, yet 870 million people are hungry and 2 billion suffer from micronutrient deficiencies. Furthermore, about 1.2 billion adults and children are overweight and 475 million are obese. Food biodiversity (i.e. food identified at the taxonomic level below the species level, and neglected/underutilized or wild species) represents a nutrition resource that is capable of addressing the multiple burdens of malnutrition by providing dietary energy, macro- and micronutrients and other beneficial bioactive constituents. There can be many reasons for differences in the nutrient content of food species, but among the most significant result from their genetic diversity.

31. **Indigenous Peoples' food systems are remarkably diverse and represent important repositories of knowledge related to healthy and resilient diets which have had minimal impact on the environment and ensured food and nutritional security.** For centuries, communities of Indigenous Peoples have been custodians of the vast majority of the planet's food and genetic resources and stewards of the diverse ecosystems and cultures which have shaped these resources. Today, food insecurity presents a serious and growing challenge among Indigenous Peoples. While no single response can solve the problem of food insecurity, strengthening and leveraging Indigenous Peoples' food systems is one important strategy in a multidisciplinary approach to improve diets and reverse negative food-related

health outcomes. Not only do these food-based approaches potentially improve nutrition and health in a sustainable manner, they also revive biocultural knowledge and heritage.

32. It cannot always be assumed that a biodiversity rich environment or landscape necessarily contributes to better diet or enhanced nutrition of individuals living in close proximity. Linking biodiversity assessments with quantitative dietary assessments in biodiverse environments should promote more ethnobiological studies to better understand why some local communities do not make more effective use of edible biodiversity. Possible barriers include: negative perceptions of indigenous wild foods; excessive women's workloads and distances involved for collection; food preparation times; and poor knowledge among local populations about the nutritional value of the indigenous wild foods in their immediate environment. If we are to promote more effective use of this biodiversity it is critically important to address these barriers through implementation of interventions such as: generation and use of better data on their nutrient composition; better awareness, including nutritional education on the benefits of edible biodiversity; domestication of priority species and integration into home gardens; and guidelines for improved use of nutritionally-rich foods from local biodiversity, including recipes adapted to modern lifestyles.

Wild foods and dietary diversity

33. **Use of wild edible plants and animals contributes to dietary diversity, improves micronutrients and vitamin intake and peoples' reported levels of satisfaction with their diet.** Wild foods are also important for spiritual and psychological health where customary beliefs or ancestor worship are prevalent. Their use is particularly pertinent where most agricultural production is centred on one or two cereals or tuber based staples which contribute the bulk of daily calorie requirements, but are low in many micronutrients and dietary diversity. Conservative estimates report the consumption of wild foods by approximately one billion people worldwide, yet the actual proportion of daily nutrient requirements supplied by wild foods is largely unknown. The consumption of wild foods is not driven solely by need or poverty, but also by culture, tradition and preference. Domestication of the most important wild food sources may help to both conserve biodiversity and to provide rural communities with better livelihood options.

34. **The use of wild foods increases during the traditional 'hungry season' when crops are not yet ready for harvest, and during times of unexpected household shocks such as crop failure or sudden illness.** The use of wild foods at such times is manifest either through direct contribution to household or individual diets, or through collection and trade to generate income for the purchase of food, medicines, or other immediate needs. There is ample evidence of such coping mechanisms around food security in the face of afflictions such as HIV/AIDS. They may also be a coping response to extreme shocks such as political unrest, conflict or war, which sometimes results in greater numbers of deaths than those from weapons. Whilst many national or regional food security indices or models focus on the net yields of key crops and average those across the population demand or calorie needs, these overlook the potentially high variability in the timing of food availability from crops. Sustainable markets also need to be developed for new wild food products and processors linked to domestic and international markets to improve livelihoods.

35. **The overuse of wild edible plants and animals may have undesirable impacts on the species used, or the structure and function of the broader systems from which they are harvested.** Ecosystem goods and services such as wild foods are used sources of food, fibre, fodder, medicine and livelihoods. A number of important drivers, and the interactions

between them, can increase or decrease the use and availability of wild foods. Ill health, land use change, climate change, unsustainable harvesting, socio-economic realities, conflict, loss of traditional knowledge, the expansion of markets and globalizing trends all have varying degrees of impact on the use and availability of wild foods. Because biodiversity hotspots often coincide with areas in which there is a higher prevalence of malnutrition, undernutrition and economic vulnerability, policies that jointly address biodiversity, development, food and associated health impacts are needed.

36. **The collection and trade in wild edible plants and animals indirectly contributes to health and well-being by providing income for household needs,** particularly in less developed countries. Aggregating across numerous local level studies, estimates of the annual value of the bushmeat trade alone in west and central Africa range between US$42 and 205 million (at 2000 values). Markets in wild foods can be observed in almost any setting throughout most of the developing world, ranging from 'invisible' inter-household trade to substantial markets in regional and national urban centres. Even cross-border, international trade is not uncommon (e.g. in bushmeat, dried fish, oils, dried insects). In some parts of China the trade in wild plant foods contributes between 15 % and 84 % of market income for different groups, representing between 4 % and 13 % of total household income. Notably, the mean price of wild vegetables was 72 % higher than that of cultivated vegetables. Larger-scale national and international markets also exist for a whole range of wild foods, although overexploitation can lead to unsustainable use.

Global Trends

37. **Access to wildlife in terrestrial, marine, and freshwater systems is critical to human nutrition, and global declines will present major public health challenges for resource-dependent human populations, particularly in developing countries.** Wildlife populations are in worldwide decline as a result of habitat destruction, over-exploitation, pollution, invasive species, and other anthropogenic causes. There is mounting evidence that terrestrial wildlife, especially in the resource-dependent regions of the developing world, is a critical source of nutrition for local people. An estimated 6 million tonnes of animals are extracted yearly from the tropics, and 88 percent of fished stocks are estimated to be fully exploited, overexploited, or depleted. The well-known progression from anemia to future disease demonstrates the far-reaching effects of lost access to wildlife, including cognitive, motor, and physical deficits. Fish provide more than 3 billion people with at least 15 % of their average per capita animal protein intake, and, low-income food deficit countries likely demonstrate much higher rates of fish protein dependence, considering the underreported nature of small-scale fisheries and lack of meat alternatives. Even a single portion of local traditional animal-source foods may result in significantly increased clinical levels of energy, protein, vitamin A, vitamin B6/B12, vitamin D, vitamin E, riboflavin, iron, zinc, magnesium and fatty acids- thus reducing the risk of globally pervasive micronutrient deficiencies.

38. **The growing uniformity of the world's food supply has major implications for food and nutrition security and the declining levels of agricultural biodiversity in the global food system is a cause for concern**. It is estimated that around 7,000 plant species have been used at various points in time for human food since the beginning of agriculture. However, only 150-200 of these species have ever been commercially cultivated. Only three of these species - rice, maize and wheat - provide more than half of the world's plant derived calories. While cereals are high in carbohydrates and energy and can provide a moderate amount of protein they tend to be low in micronutrients and often end up as highly processed foods. It is further estimated that only 12 crops and 5 animal species provide

three-quarter of global food today highlighting the narrow food base we depend on and the general vulnerability of agriculture and food production.

39. **Agricultural programmes and policies often aim to increase the production of a few staple crops to eliminate hunger, and measure their success in terms of the quantity of available food or dietary energy supply, but staple crops do not provide sufficient micronutrient supplies.** Maximizing food quality of agricultural systems has not been a priority of modern agriculture. This is starting to change with an increasing focus on 'nutrition-sensitive agriculture'. Many countries and agencies also attempt to combat malnutrition with short-term health and nutrition interventions such as supplementation, Ready-To-Use Therapeutic Foods (RUTFs), fortification and sporadic health and nutrition policies and programmes. Not all biofortification is the result of transgenics but is often conventional breeding. Not only are these interventions unsustainable, but in recent years, doubts have been articulated with respect to their efficacy. While fortification and biofortification are often promoted as cost-effective solutions to global undernutrition, addressing the problem of micronutrient malnutrition through biofortification of staple crops would fail to address the problem effectively, because a healthy, balanced diet requires a variety of foods and nutrients, and not single micronutrient additions to starchy staples. While some micronutrient deficiencies are easily measured (e.g. vitamin A and iron), deficiencies of 100 or more vitamins, minerals, individual amino acids and fatty acids, and other beneficial bioactive food components are of concern. Such deficiencies can only be avoided by consuming a variety of foods, not by, for example, biofortifying rice with a transgenic biosynthetic pathway for a pro-vitamin A carotenoid. Nature provides an abundance of wild and cultivated food species that can be used as an equally valid alternative for the promotion good nutrition and health.

40. **Globalization, poverty, modern agricultural practices and changes in dietary patterns have also led to a "nutrition transition".** The nutrition transition is the process by which development, globalization, poverty and subsequent changes in lifestyle have led to excessive calorific intake, poor quality diets and low physical activity. The selective specialization in a smaller number of crops and crop genotypes has also made some crops less resilient to diseases and limited the range of available nutrients. While staple crops such as wheat and rice are increasing in abundance, their nutritional value tends to be decreasing. An alarming dietary shift from traditional foods and healthy diets towards consumption of poor-quality processed foods, often available at lower prices, has taken place. In many parts of the world, this is accompanied by increased consumption of meat. These trends have contributed to the dramatic emergence of obesity and associated chronic diseases. The nutrition transition is particularly prevalent among indigenous peoples, who tend to suffer higher rates of health disparities and lower life expectancy regardless of geographic location.

41. **Climate change will not only affect food production systems but also the nutritional content of foods through rising levels of atmospheric carbon, causing significant health tolls for malnutrition.** Climate change will affect a number of crops including C3 grains and legumes, crops that billions of people around the world rely on as their primary source of iron and zinc. Rising CO_2 will lead to reductions of 5-10% in the iron and zinc content of the edible portion of these crops and increasing the burden of disease for these deficiencies that already cause a loss of 63 million life-years annually. Moreover, recent studies investigating the physical, biological and human responses to climate change in 67 marine national exclusive economic zones, which yield approximately 60% of global fish catches, have found that there would be increased productivity at high latitudes and decreased productivity at low/mid latitudes, with considerable regional variations. The productivity of fisheries in

South and Southeast Asia will be particularly negatively affected by climate change despite increased productivity in some areas. While models suggesting potential for meeting dietary fish demand in the medium-term have been developed, these can be heavily reliant on aquaculture which itself may have heavy associated environmental burdens.

Ways Forward – Food and Nutrition

42. **Inter-disciplinary analysis and cross-sectoral collaboration is essential to ensure the mainstreaming of biodiversity into policies, programmes and national and regional plans of action on food and nutrition security and ultimately the better conservation and sustainable use of nature's bounty.** While there has been some convergence between the agriculture, environment, health and nutrition communities toward understanding the interdependence between human and ecosystem health, and how agricultural biodiversity plays a role in maintaining both, much more is needed to yield the necessary inter-disciplinary analysis and cross-sectoral approaches required to better understand and address nutrition and environmental sustainability.

43. **Key needs include generation, compilation and dissemination of more nutrient composition data; development and administration of food consumption/dietary assessment surveys on food biodiversity; and explicitly characterization of food systems' and ecosystems' ability to provide sustainable diets.** These initiatives would create a base of reliable reference evidence that acknowledges food biodiversity's actual and potential role in reducing malnutrition, informing multiscalar decisions and contributing to multisectoral policy instruments and the integration of biodiversity and nutrition elements in agricultural programmes and policies. Combined, this data can help achieve or improve sustainable diets that are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, and nutritionally adequate, safe and healthy; while optimizing natural and human resources. The data can also bridge nutrient gaps with local food biodiversity instead of supplements, vitamin injections, fortificants and RUTFs, and will contribute to food and nutrition goals and international initiatives including the Millennium Development Goals and the Zero Hunger Challenge.

NON COMMUNICABLE DISEASES AND MICROBIAL COMMUNITIES

44. **The interactions of microbes within the complex microbiome have significant implications for both ecology and human health, and influence both the physiology of and susceptibility to disease.** The relationships our individual bodies have with our microbiomes is a microcosm for the vital relationships our species shares with countless other organisms with which we share the planet. The bacteria, viruses, fungi, and protozoa of which microbes are comprised play an important role in the processes that link environmental changes and human health.

45. **Understanding the factors that influence functional and compositional changes in the human microbiome can contribute to the development of therapies that address the gut microbiota and corresponding diseases**. The realization that humans are not merely "individuals", but rather complex ecosystems (>90% of our cells are microbial) may be one of the major advances in our understanding of human health in recent years, particularly in relation to the gut microbiota which can be thought of as a major *organ*, entirely composed of microbes.

46. ***Environmental* microbial ecosystems are in constant dialogue and interchange with the human *commensal* ecosystems.** This critical interaction coupled with the well established immunoregulatory roles of microorganisms are a credible foundation for considering microbial biodiversity a life-sustaining "ecosystem service". Understanding "microbial diversity" as an ecosystem service may contribute to bridging the chasm between ecology and medicine/immunology, by considering microbial diversity in public health and conservation strategies aimed at maximizing services obtained from ecosystems.

47. Our physiological requirements for microbial biodiversity are evolutionarily determined and we have an evolved requirement for transfer of genes from environmental organisms to organisms already present in the microbiota (horizontal gene transfer). All complex plants and animals (including humans) have microbiota without which they could not survive. Microbes from the environment supplement and diversify the composition of the commensal microbial communities that we pick up from mothers and family, which in turn play significant roles from a physiological perspective. In addition to supplementation of the commensal microbiota by organisms from the natural environment, the adaptability of the human microbiota (for example, to enable digestion of novel foods) depends upon acquiring genes encoding necessary enzymes from the environment by horizontal gene transfer. Therefore we need appropriate contact with potential sources of genetic innovation and diversity, and our adaptability is threatened by loss of biodiversity in the gene reservoir of environmental microbes.

48. **Several categories of organism with which we co-evolved play a role in setting up the mechanisms that "police" and regulate the immune system**. Some of the organisms that regulate the immune system in hunter-gatherer communities have detrimental effects on health, and so are eliminated by modern medicine in high-income settings. Helminth infections are the most obvious example. This increases the importance of the immunoregulatory role of microbiota and the microbial environment in high-income settings, where these categories of organism need to compensate for loss of the "Old Infections".

49. **Biodiversity loss in the wider environment may lead to reduced diversity in the human microbiota, which itself can lead to immune dysfunction and disease, including various chronic inflammatory disorders**. Urbanization and loss of access to green spaces are not only increasingly discussed in relation to NCDs but have also been linked to a failure of the immune system to adapt to microbe-poor environment. Half of the world's population already lives in urban areas and this number is projected to increase markedly in the next half century, with the most rapid increase in low- and middle-income countries. Microbial composition and interaction may lead to new insights on the health impacts of urbanization.

50. **Reduced contact of people with the natural environment and biodiversity can have adverse impacts on the human microbiota and its immunomodulatory capacity, particularly among urban populations worldwide**. Recent evidence suggests that declining contact with some forms of life may contribute to the rapidly increasing prevalence of allergies and other chronic inflammatory diseases among urban populations worldwide, through impacts on commensal microbiota (e.g. skin and gut microflora) and their role in immune function. In high-income settings in particular there are simultaneous increases in several chronic inflammatory disorders in which regulation of the immune system is failing, and immune responses to forbidden targets are occurring. Immune responses to our own tissues lead to autoimmune diseases (type 1 diabetes, multiple sclerosis); immune responses to harmless allergens and foods lead to allergic disorders (eczema, asthma, hay fever);

immune responses to gut contents contribute to inflammatory bowel diseases (ulcerative colitis, Crohn's disease). Combined, these findings suggest an important opportunity for cross-over between health promotion and education on biodiversity.

51. **Failing immunoregulatory mechanisms partly attributable to reduced contact with the natural environment and biodiversity, contribute to metabolic disorders, obesity and type 2 diabetes, as well as to increased prevalence of several cancers.** In high-income settings several cancers rise in parallel with the large increases in chronic inflammatory disorders. In such settings, there is often continuous background inflammation even in the absence of specific chronic inflammatory disorders. People with persistently raised circulating levels of inflammatory mediators are prone to metabolic syndrome, type 2 diabetes and obesity. The inflammatory mediators cause insulin resistance and upset the neuroendocrine circuits that control obesity. At the same time, chronic inflammation drives mutation, and provides growth factors and mediators that stimulate vascularisation and metastasis.

52. **Chronically raised levels of circulating mediators of inflammation, caused by failing immunoregulation, are common in high-income countries, and are associated with a risk of depression**, which is predicted to become the major affliction of mankind within a few decades. In low-income settings where there is high exposure to microbial biodiversity, inflammation occurs when needed, for example during an episode of infection, but then switches off completely. In high income settings control of inflammation often fails, and chronically raised inflammatory mediators lead to depression, and probably to reduces stress resilience.

53. **Innovative design of cities and dwellings might be able to increase exposure to the microbial biodiversity that our physiological systems have evolved to expect**. In high-income settings several very large studies reveal significant health benefits of living near to green spaces. The benefits are greatest for people of low socioeconomic status. Recent data suggest that the effect is not due to exercise, and exposure to environmental microbial biodiversity is a plausible explanation. This provides a strong medical rationale for increased provision of green spaces in modern cities. It might be sufficient to supplement a few large green spaces with multiple small green spaces that deliver appropriate microbial diversity.

INFECTIOUS DISEASES

54. **Pathogens play a complex role in biodiversity and health, with regulating benefits in some contexts and threats to biodiversity and human health in others.** The relationships between infectious pathogens and host species are complex; disease and microbial composition can serve vital regulating roles in one species or communities while having detrimental effects on others. Microbial dynamics, and their implications for biodiversity and health, are multifactorial; similarly, the role of biodiversity in pathogen maintenance and prevalence is appears to be multifactorial and is not fully understood.

55. **Human-mediated changes in ecosystems, such as modified landscapes, intensive agriculture, and antimicrobial use, are increasing infectious disease transmission risks and impact.** Approximately two-thirds of known human infectious diseases are shared with animals, and the majority of recently emerging diseases are associated with wildlife. Increasing anthropogenic activity is resulting in enhanced opportunities for human-environment contact and facilitating disease spread, especially from animals. Changes in land use and food production practices are among leading drivers of disease emergence in

humans. At the same time, pathogen dynamics are changing. While pathogen evolution is a natural phenomenon, factors such as global travel, climate change, and antimicrobial use are rapidly affecting pathogen movement, host ranges, and persistence and virulence. Beyond direct infection risks for human and animals, such changes also have implications for food security and medicine.

56. **Areas of high biodiversity may have high numbers of pathogens, yet biodiversity may serve as a protective factor for preventing transmission, and maintaining ecosystems may help reduce exposure to infectious agents.** While the absolute number of pathogens may be high in areas of high biodiversity, disease transmission to humans is highly determined by contact, and in some cases, biodiversity may serve to protect against pathogen exposure through host species competition and other regulating functions. Increased host species diversity may be correlated with reduced disease risk in some situations (a theory termed the "dilution effect"), although this practice has not been consistently observed. Limiting human activity in biodiverse habitats may reduce human exposure to high-risk settings for zoonotic pathogens while serving to protect biodiversity.

57. **The rapidly growing number of invasive species cause significant impacts on human health, and this effect is expected to further increase in the future, due to synergistic effects of biological invasions and climate change.** Preventing and mitigating biological invasions is not only is crucial to protect biodiversity, but can also protect human health. The number of invasive species is increasing globally as a consequence of the globalization of the economies, and the trend is expected to intensify in the future due to synergistic effects with climate change. Invasive species not only impact biodiversity, but also affect human health causing diseases or infections, exposing humans to bites and stings, causing allergenic reactions, and facilitating the spread of pathogens.

MEDICINES

Traditional Medicine

58. **Medicinal and aromatic plants (MAPs) are used in the pharmaceutical, cosmetic and food industries, the great majority of which are sourced from the wild. The global use and trade in medicinal plants and resources is high and growing**. Plants used in traditional medicine are not only important in local health care, but are important in international trade based on broader commercial use and value. Globally, an estimated 60,000 species are used for their medicinal, nutritional and aromatic properties, and every year more than 500,000 tonnes of material from such species are traded. A complete list of all plants used in traditional medicine does not exist, but at least 30,000 species of plants with documented use are included in the Global Checklist. It is estimated that the global trade in plants for medicinal purposes reaches a value of over 2,5 billion USD and is increasingly driven by industry demand. Various body parts and secretions derived from wildlife are also included in traditional medicine pharmacopoeia. Institutionalized traditional medicine manufacturers are also investing in the development of new products and there is an increasing reverse 're-engineering' process being undertaken by researchers, where novel medicines or medical therapies are being developed using traditional processes.

59. **Threats to medicinal plants, animals and other medicinal resources are on the rise**. Wild plant populations are declining with one in five species estimated to be threatened with extinction in the wild. Conservation status of medicinal plants is little understood but animals (amphibians, reptiles, birds, mammals) used for food and medicine are more

threatened than those not used. There is a clear need to continue efforts at developing assessment methods and indicators to monitor progress, especially towards the Strategic Plan for Biodiversity 2011-2020 and the underlying Aichi Biodiversity Targets and specifically its Target 14.

60. **Traditional medical knowledge spans various dimensions relating to medicines, food and nutrition, rituals, daily routines and customs. Local pharmacopoeia have been developed over a long period of human–biodiversity interactions and are unique in terms of compatibility to local contexts, easy accessibility of resources and hence, cost efficacy.** Traditional knowledge on health can range from home level understanding of nutrition, management of simple ailments and reproductive health practices to treatment of serious chronic illnesses or addressing public health requirements. Links to geography, community, worldviews, biodiversity and ecosystems based on specific epistemologies make traditional health practices diverse and unique. While it might be entirely plausible that communities in similar ecosystems with similar geographical characteristics use similar medicines, there are bound to be differences in the process of preparation and delivery of the medicine and socio-cultural connotations to the understanding and management of disease.

61. **There is no single approach to traditional medical knowledge. Traditional knowledge is not restricted to any particular period in time, and constantly undergoes reevaluation based on local contexts.** It can be seen that some of the traditional medical systems are codified, and some even institutionalized. These range from highly developed ways of perception and understanding, classification systems (ethno-taxonomies) to metaphysical precepts. By extension, level of expertise is heterogeneous and therefore internal validation methods differ substantially despite an underlying philosophical principle of interconnectedness of social and natural worlds.

62. ***sui generis* models may need to be developed to secure rights over intangible and tangible resources related to traditional medical knowledge.** Since most of the traditional environmental and medical knowledge among communities is verbally maintained, revival of the social processes of their generation, preservation and transfer within communities' needs to be studied. Traditional medical knowledge is often an inspiration for industrial R&D processes in bio-resource based sectors, necessitating mechanisms to secure appropriate attribution and sharing of rights and benefits with knowledge holders, as set out both in the Nagoya Protocol on Access to genetic resources and equitable sharing of benefits arising from their commercial utilization. It would be beneficial to strengthen and promote existing tools, databases and registers and intellectual property rights that are sensitive to community values, while also promoting innovation and good practices as active social traditions. Protection measures, whether within current IPR system or *sui generis,* must be responsive to changing business models and product development trends.

63. **Sustainable use of medicinal resources can provide multiple benefits to biodiversity, livelihoods and human health, in particular, relating to their affordability, accessibility and cultural acceptability**. Overharvesting, habitat alteration, and climate change are among major drivers of declines in commercially important wild plant resources used for food and medicinal purposes. These pose a dual threat to wild species and to the livelihoods of collectors, who often belong to the poorest social groups. Medicinal resources also have high therapeutic and social values, especially among indigenous and local communities, and reduction in populations affects the ability of these groups to seek and secure resources that impact their health and wellbeing. Linking economic development objectives can also incentivize sustainable use of medicinal resources. The value chains of traditional medicine

and medicinal resources tend to be linked to various sectors and many of the primary supplies are found within the same ecosystems. Ensuring equitable economic returns to local communities by promoting value added activities at the local level can help to harness their knowledge local communities medicinal resources and promote their sustainable use. Encouraging enterprise development based on medicinal and nutritional resources and services, and development of new, appropriate and feasible technologies that could enhance productivity and quality of resources, would further complement conservation measures.

64. **Improving public health outcomes and achieving objectives of 'Health for All' and 'Good Health at Low Cost' requires leveraging and strengthening patronage for traditional medical care.** It has been estimated that more than one-third of the population in many developing countries do not have access to modern healthcare, and are dependent on traditional medical systems. This is indicative of the high patronage of and dependence on traditional health practitioners to provide care to people with inadequate access to modern health infrastructure. Studies have shown that a pluralistic approach integrating natural resources and medical knowledge can enable better health outcomes. Diversified approaches for strengthening public health systems are needed, and their formulation must be sensitive to local priorities and contexts. The need to re-integrate traditional medical approaches to the public health armamentarium is gaining greater political and social acceptance.

Ways Forward – Traditional Medicine

65. **Assessment methods to inventorize resources and knowledge used in health care need to be developed.** A number of steps are taken by governments, international organizations, non-governmental organizations (NGOs), communities and the private sector to address the issue of sustainable use of medicinal plants and animals, however, more efforts at all levels are needed. Internationally, a substantial number of plants and animals are included in CITES appendices to monitor and limit impacts of international trade, supporting sustainable levels of use. Within the CBD agenda, Global Strategy for Plant Conservation (GSPC) provides the framework and results-oriented Targets for understanding of plant resources, their conservation, sustainable use and the preservation of traditional knowledge around the use of plant resources. Building on these initiatives, it is imperative to conduct integrated assessments of biological resources and traditional health practices in an ecological and community context. This would enable prioritizing conservation and development strategies and could capture details that may not figure into mainstream assessments. The inventorizing process would also entail identification, documentation, participatory and interdisciplinary assessment and promotion of relevant practices for rural community health and well-being, and strengthen conservation and sustainable harvest approaches.

66. **There is a clear a need to develop and promote appropriate integrative methodologies for assuring quality, safety and efficacy of traditional medical practices based on standards within and across medical systems.** Some efforts have been made to involve interdisciplinary methods combining social science methods with expert evaluation to assess and validate traditional medical interventions and sustainable use of medicinal resources. It is imperative to strengthen efforts and initiatives seeking to develop novel products for global health through approaches such as ethnopharmacological and biotechnological research as well as new approaches such as reverse pharmacology. Research into new methods of production that will reduce the biomass requirements of natural resources is another area that requires attention.

67. **Cross learning between different knowledge systems and disciplines is needed.** Traditional approaches to health care have been tested over time empirically albeit without adequate documentation. A major challenge is to document such experiences and thereby foster a participatory learning process to identify and supplement current practices in a culturally sensitive way. Studies related to biological resources and management and traditional medicine should be promoted through formal, informal and informal learning processes. There is also a need to strengthen policy-relevant research in these domains. Reflexive capacity development and intercultural learning exchanges between experts are also needed. In particular, there is a need to develop reflexive methods of capacity development that allow and further learning between experts external and internal to the traditional medical systems, at various levels of operation, including the sustainable use and protection of the resources stemming from medicinal flora and fauna from the wild.

68. **The different roles of traditional medical practitioners and carriers of such knowledge need to be recognized and strengthened.** Carriers of such knowledge are seen to have high social legitimacy and are often the first points of health intervention in marginalized areas. Measures to strengthen and leverage on their capacities and skills to ensure equitable access to healthcare should be strengthened, and traditional healers should be recognized and appropriately integrated in the healthcare system through appropriate and culturally sensitive accreditation and processes. This further implies the need to develop cost-effective measures to test safety, efficacy and quality of traditional medicines. Efforts at revitalizing household health and food traditions should also be made.

69. **Expansion of partnerships with different stakeholders and exploring appropriate market-based instruments that could enable sustainable and responsible utilization of resources in traditional medicine is required**. Sustainable medicinal resource management for both captive-breeding and wild-collection is crucial for the future of traditional medicine, that involves all stakeholders including conservationist, private healthcare sector, medical practitioners and its consumers. Increase in partnerships at local, national, regional and global levels by supporting/facilitating enhanced networking among various stakeholders, such as in value chain partnerships, learning partnerships among and between peer groups is important. Good examples include the development of standards and certification schemes such as the FairWild Standard that was developed by TRAFFIC, IUCN, WWF and other partners in a multistakeholder, inclusive consultation process as a best practice tool to verify that wild collection of plants in ecologically sustainable and trade is equitable. A complementary initiative is the BioTrade Verification Framework for Native Natural Ingredients developed by the Union for Ethical BioTrade (UEBT). These efforts enable monitoring of collection and trade practices, and tracing the movement of resources, in addition to fostering sustainable use practices allowing benefits to different actors in the supply chain. Furthermore, such partnerships should enable the facilitation of financial support mechanisms to promote R&D, capacity development and awareness activities related to traditional medical knowledge. Strengthening synergies across policies is also necessary.While several multilateral policy bodies such as the WHO, CBD, FAO and others play a strong role in setting relevant policy agendas, the scope and mechanisms for inter-agency co-operation and to synergize policy practice linkages need to be further enhanced. This is also applicable to national level policy setting and implementation.

MODERN MEDICINE

Contribution of biodiversity to the development of pharmaceuticals

70. **Biodiversity has been an irreplaceable resource for the discovery of medicines and biomedical breakthroughs that have alleviated human suffering.** Drugs derived from natural products may perhaps be the most direct and concrete bond that many may find between biodiversity and medicine. Among the breakthroughs that dramatically improved human health in the twentieth century, antibiotics rank near the top. The penicillins as well as nine of the thirteen other major classes of antibiotics in use, derive from microorganisms. Between 1981 and 2010, 75% (78 of 104) of antibacterials newly approved by the USFDA can be traced back to natural product origins. Percentages of antivirals and antiparasitics derived from natural products approved during that same period are similar or higher. Reliance upon biodiversity for new drugs continues to this day in nearly every domain of medicine.

71. **For many of the most challenging health problems facing humanity today, we look to biodiversity for new treatments or insights into their cures.** Most of the medicinal potential of nature potential has yet to be tapped. Plants have been the single greatest source of natural product drugs to date, and although an estimated 400,000 plant species populate the earth, only a fraction of these have been studied for pharmacologic potential. One of the largest plant specimen banks, the natural products repository at the National Cancer Institute, contains ~60,000 specimens, for instance. Other realms of the living world, especially the microbial and marine, are almost entirely unstudied and hold vast potential for new drugs given both their diversity and the medicines already discovered from them.

72. **Far greater than what individual species offer to medicine through molecules they contain or traits they possess, an understanding of biodiversity and ecology yield irreplaceable insights into how life works that bear upon current epidemic diseases.** Consider the multiple pandemics that have resulted from antibiotic resistance. Human medicine tends to use a paradigm for treating infections unknown in nature which is treating one pathogen with one antibiotic. Most multicellular life (and a good share of single cellular life) produces compounds with antibiotic properties but never uses them in isolation. Infections are attacked, or more often prevented, through the secretion of several compounds at once.

Antibiotics and Antimicrobials

73. **Antibiotic and antimicrobial use can alter the composition and function of the human microbiome and limiting their use can provide biodiversity and health co-benefits.** The human microbiome contains ten times more microorganisms than cells that comprise the human body and antibiotic use can dramatically alter its composition and function. Although much of the microbiome and its relationship to its host remains unexplored, already apparent is that changes to the variety and abundance of various microorganisms, as can occur with antibiotic use, may affect everything from the host's weight and the risk of contracting autoimmune disease, to susceptibility to infections. The microbiome may also be able to affect mood and behavior. The use of antibacterial products and antibiotics may also be linked to the increase in chronic inflammatory disorders, including allergies such as asthma and eczema, because they reduce exposure to microbial agents that set up the regulation of the immune system. A growing body of literature is predicated on the finding that certain environments, such as those found in relatively urban and affluent communities, do not support the development of a healthy microbiota. Limiting the use of antimicrobial agents could provide potential co-benefits for human health and biodiversity, reducing

chronic inflammatory diseases through a healthy and more diverse human microbiota while also reducing the risk of emerging disease from antibiotic-resistant strains and the potential impacts of antibiotics on ecosystems more broadly.

74. **The over- and misuse of antibiotics, in particular those used in the livestock sector, has cultivated numerous highly resistant bacterial strains.** In some instances, resistant bacterial strains cannot be effectively treated with any currently available antibiotic. Limiting the use of antibiotics and antimicrobials in agricultural practices and food production systems can achieve public health and biodiversity co-benefits. Current industrial agricultural practices contribute to ecosystem degradation, air and water pollution and soil depletion and rely heavily on the use of antibiotics, which may lead to antibiotic resistance and reduced efficacy in subsequent use for medical applications. From a health perspective, the use of antimicrobials and antibiotics may disrupt microbial composition, including the relationships between hosts and their symbiotic microbes, and lead to diseases. At the same time, antibiotic resistance in both human and wildlife can pose serious threats to public health. Aside from its potential to cultivate resistance, antibiotic use also carries the potential to disrupt.

Impacts of pharmaceuticals on biodiversity

75. **The release of pharmaceuticals and Active Pharmaceutical Ingredients (APIs) into the environment can have an impact on biodiversity, ecosystems and ecosystem service delivery.** Most pharmaceuticals are designed to interact with a target (such as a specific receptor, enzyme, or biological process) in humans and animals to deliver the desired therapeutic effect. If these targets are present in organisms in the natural environment, exposure to some pharmaceuticals might be able to elicit effects in those organisms. Pharmaceuticals can also cause side effects in humans and it is possible that these and other side effects can also occur in organisms in the environment. It is inevitable that during the life cycle of a pharmaceutical product, APIs will be released to the natural environment, including during the manufacturing process via human or domestic animal excretion into sewage systems, surface water or soils, when contaminated sewage sludge, sewage effluent or animal manure is applied to land. A range of pharmaceuticals, including hormones, antibiotics, non-steroidal anti-inflammatory drugs (NSAIDs), anti-depressants and antifungal agents have been detected in rivers and streams across the world. APIs may also be released into the soil environment when contaminated sewage sludge, sewage effluent or animal manure is applied to land. Veterinary pharmaceuticals may also be excreted directly to soils by pasture animals.

76. **Endocrine disrupting chemicals (EDCs) found in many household, food and consumer products have adverse effects on the health of terrestrial and marine wildlife and human health.** The use of contraceptive and veterinary growth hormones have been linked to endocrine disruption and reproductive dysfunction in wildlife. They also affect both male and female human reproduction, and have been linked to prostate cancer, neurological, endocrinological, thyroid, obesity, and cardiovascular problems. Biodiversity has also been a good monitor for some of these human health problems. In some cases, health specialists were alerted to the scale of a potential problem through changes originally recorded in wild fish populations.

PHYSICAL, CULTURAL AND MENTAL WELL-BEING

Physical Health

77. **Access to natural green space can increase levels of physical activity with benefits for health;** however, the potential that green space can offer for promoting and enhancing physical fitness is still not fully recognised. Among populations for which access to open countryside is limited, particularly those in poorer inner-urban areas of large cities, access to green spaces in the urban environment can encourage regular physical activity and improve life expectancy and decrease health complaints. Efforts to develop biodiverse settings, including wildlife-rich gardens, can also boost physical activity in sedentary and vulnerable patients and residents. There is evidence that biodiversity encourages use of urban green spaces. The benefits of physical activity include reduced risk of several non-communicable diseases, as well as improved immune function. Engaging in regular physical activity has also been linked to improved mental health, and can facilitate greater social connections and independence (particularly in elderly persons) and combat the impacts of physical and mental disability. The psychological benefits and sometimes social outcomes, may also increase motivation to exercise. Much of this is thought to be due to a favourable environment for people to exercise, improving motivation to continue physical activity - parks and tree-lined streets have a specific significant relationship with increased longevity. Activities in which exercise becomes secondary to social or environmental benefits (e.g. social walking, community gardening) appear to be more sustainable than activities where exercise is the primary driver. Children in particular increase their physical activity when outdoors, and are attracted to nature.

78. **Significant changes to local biodiversity or ecosystem sustainability can have specific and unique impacts on local community health where the physical health of a community is directly influenced by or dependent upon ecosystem services, particularly regarding access to diverse food and medicinal species.** Indigenous and local communities often act as stewards of local living natural resources based on generations of accumulated traditional knowledge, including knowledge of agricultural biodiversity, and biodiversity that supports traditional medicinal knowledge. Similarly, where local traditions and cultural identity are closely associated with biodiversity and ecosystem services, or where biodiversity is an important aspect of sense of place and community cohesion, then changes to the availability and abundance of such resources can have a detrimental impact on community well-being, with implications for mental and physical health, social welfare and community cohesion.

79. **A better understanding of the relationship between exercise and wildlife-rich open space is required to support efforts to increase levels of physical activity important to human health.** There is a growing interest in many countries in development of strategies for promoting and enhancing “green and blue infrastructure” (terrestrial and aquatic environments) within tourism, public health and environmental policies. A greater understanding of associated economic benefits will also strengthen cost-benefit assessments for policies to maintain and create green space.

Cultural well-being

80. **Biodiversity is often central to cultures, cultural traditions and cultural well-being.** Species, habitats, ecosystems, and landscapes influence and inhabit forms of music, language, art, literature and dance. They form essential elements of food production systems, culinary traditions, rituals, worldviews, attachments to place and community, and social systems.

Biodiversity also influences value systems and modes of conduct, including regulations of behaviour and local institutions. The links between biodiversity and cultural diversity have been the subject of much discussion and research in recent years. The increasing awareness of culture as a pillar of sustainable development, and increasing focus on the central role of biodiversity in achieving sustainable development goals, have opened many avenues for integrated approaches to the conservation of living natural resources and the cultures and non-tangible heritage that have evolved with them.

81. **Culturally-competent health practice must account for the influence of culture on attitudes, beliefs and behaviours, including the relationship between people and their local biodiversity and ecosystem services.** The relationship between culture and population health is complex. The delivery of primary health care at the community level is generally organised around predominant local cultural norms, but must also increasingly account for cultural diversity and the cultural characteristics of minority groups.

82. **Therapeutic and bio-cultural landscapes are an important dimension to achieve health at the local level.** Survival and vitality of knowledge and resources depend on the socio-cultural contexts in which they are embedded. Typically, such knowledge and resources are found to be most vibrant among communities (specifically, indigenous and local communities) close to culturally important landscapes. These could relate to socio-ecological production landscapes (e.g., Satoyama in Japan) or conservation systems (e.g., sacred groves, ceremonial sites) or therapeutic landscapes (e.g., sacred healing sites). Such landscapes and related traditional knowledge practices contribute immensely to health and well-being, therefore necessitating a close inquiry into the functional interlinkages within such systems, and maintenance of their dynamism.

83. **While many community-specific links between health, culture and biodiversity have been documented and measured, much of the evidence for a more universal relationship is sparse beyond anecdotal accounts.** However, there is growing recognition of the role of biodiversity and ecosystem services in shaping broad perspectives of quality of life. The WHO Quality Of Life Assessment (WHOQOL) was devised to determine an individual's quality of life in the context of their culture and value systems; use of the WHOQOL method has shown that the environmental domain – including aspects of safety, security, access to resources and interaction with local environments – is an important part of the quality of life concept.

Mental health and well-being

84. **Exposure to green space may have positive impacts on mental health.** The WHO reports that people who suffer from mental illness may be at disproportionately higher risk of disability and mortality. Depression accounts for 4.3% of the global burden of disease and is among the largest single causes of disability worldwide, particularly for women. The economic consequences are also significant: a recent study estimated that the cumulative global impact of mental disorders in terms of lost economic output will amount to US$ 16.3 billion between 2011 and 2030. Some studies of populations in developed countries have suggested that adults exposed to green space report fewer symptoms and a lower overall incidence of certain diseases than others, and that the relationship is strongest for mental illnesses such as depression, anxiety and stress. Other research has indicted that experience of nature can reduce recuperation times and improve recovery outcomes in hospital patients.

85. **The interaction with nature – including domestic animals, and wild animals in wild settings – may contribute to treatments for depression, anxiety, and behavioural problems, including children.** Contact with nature is important to childhood development, and children who grow up with knowledge about the natural world and the importance of conservation may be more likely to conserve nature themselves as adults. Conversely, it has been stipulate that children in developed countries increasingly suffer from a "nature-deficit disorder", due to a reduction in the time spent playing outdoors due to increased use of technology and parental / societal fears for child safety. Some research has suggested that some children, particularly those from urban areas, are fearful of spending time in certain natural habitats (woodland and wetland) owing to perceived threats from isolation, wild animals or the actions of other people.

86. **Awareness of endemic biodiversity and endemic landscape features has been associated with community-cohesion and psychological well-being through an enhanced or locally unique sense of place.** The functional role of biodiversity – as opposed to a general role for exposure to natural landscapes or related sounds or images - has often not been clearly demonstrated, although some studies have suggested that the quality of greenspace, which is measured as a composite of a number of factors which include measures of biodiversity – is more important than the relative quantity, as measured by area of greenspace.

PART III

CROSS-CUTTING ISSUES
(TO BE COMPLETED)

Disaster Risks, Resilience & Recovery

87. **Disasters may be precipitated by impacts on critical ecosystems or the collapse of essential ecosystem services.** The term "disasters" may refer to natural or anthropogenic events; natural disaster events may be classed as biologic (e.g. infectious disease epidemics, pest infestations, animal stampedes), geophysic (e.g. volcanic eruption, earthquake, avalanche) or climatic (e.g. flooding, storm, extreme weather, wildfire). Human-induced disasters may include conflict, pollution events, and geophysical events related to human activity (e.g. earthquake or landslip due to development or exploration). They may be precipitated by impacts on ecosystems or essential life supporting services.

88. **Increasing evidence suggests that the number, nature and scale of (at least certain types of) natural disasters is changing, with more mid- and small-sized disasters now occurring.** The ongoing, cumulative and corrosive effects of small localised events on the assets – including biodiversity – and livelihoods of the poor may, in the long-term, have the same effects as natural hazards that can lead to larger disasters. It may also result in greater loss of life, high economic costs and damage, loss of livelihood, and significant – possibly lasting – damage to critical ecosystems. It is widely acknowledged that the nature and context of many natural disasters is changing – rapid-onset, one-off disasters are no longer considered the norm; many locations and communities are experiencing greater susceptibility to repeated disaster events, with longer term emergencies on the increase.

89. **Natural disasters can have a profound impact on ecosystem structure and functioning, and negatively affect human well-being (livelihoods, food security and health).** Experience of natural disasters in recent years, including tsunamis and extreme weather events, has demonstrated the protective effect natural ecosystems can have in reducing disaster risk

and impact for communities, as well as the risk which ecosystem degradation can have in increasing disaster risk and vulnerability. Damage to ecosystems weakens their protective value with regard to disaster prevention and impact mitigation, as well as their provisioning value in the aftermath of disasters while recovery is taking place. Sustainable effective strategies for disaster preparedness, prevention, mitigation, response, recovery and related activities rely on biodiversity, in particular the services provided by healthy ecosystems.

90. **Competition over access to ecosystem goods and services can contribute to, and become a cause of, conflict, with consequences that can negatively impact ecosystem goods and services in both the short- and long-term.** Greater recognition needs to be given to the potential positive role that conservation and ecosystem management can play in conflict prevention and resolution and peace building, while the converse also holds. In the context of disaster prevention, relief and recovery, there is often a disconnect between environmental policies, recommendations and intentions of key agencies, civil society, government authorities and donors and the need for practical actions at the field and community levels.

91. **The creation of disaster-resilient societies is increasingly tied to and dependent upon resilience in ecosystems, and sustainability and security in the flow and delivery of essential ecosystem goods and services** – not only those directly associated with resilience to immediate disaster impacts, but also those that normally support communities and wider society. Long-term health status is an important indicator of the resilience of a community – as a marker for capacity to overcome or adapt to health challenges and other social, environmental and economic pressures. Communities whose ability to overcome current challenges are affected by ecosystem degradation at the time of a disaster event – natural or man-made – are likely to be significantly more vulnerable to disasters than communities with greater ecological security.

92. **In order to help translate resilience science into effective policy and practical action, some standard definition and measurements of resilience are necessary, though both have proved difficult to attain.** The Intergovernmental Panel on Climate Change has described resilience as "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions". Interest in the emerging science of resilience has grown rapidly in recent years, due in large part to an increased awareness amongst policy makers and concerns over the need for long-term strategies to address problems in international development, disaster risk, ecosystem disruption and climate change adaptation.

93. **The conservation and management of agricultural biodiversity, including crop genetic resources, crop wild relatives and traditional seed varieties, can be an important aspect of post-disaster recovery and relief efforts.** For example, recent experience in communities affected by conflict, famine and drought has demonstrated the value of native seed stocks in maintaining food system resilience and in supporting recovery efforts. The resilience of seed systems is a key element in promoting food and nutrition security amongst vulnerable populations.

94. **New environmental impacts often occur post-emergency with an increased demand for certain natural resources which can place additional stress on specific ecosystems (such as groundwater resources) and their functioning.** Poorly planned and co-ordinated disaster

responses have sometimes caused significant degradation of many ecosystems, with impacts often extending beyond the sites where response measures were applied. Displaced groups – including refugees and internally displaced peoples – may be associated with significant impacts on the environment, including additional pressures on biodiversity and ecosystem services, which potentially can lead to increased vulnerability or conflict with other (host) communities. However, research has demonstrated both negative and positive impacts on flora and fauna, energy and heating sources, water bodies, soil quality, environmental sanitation. Effective responses that support impacted groups while also avoiding or limiting longer term risks associated with further degradation of ecosystems (or disrupted access to ecosystem services) depend upon appropriate consideration of local factors, including needs assessments that account for cultural, environmental and geographic complexities.

Tools and Metrics

95. **Translation and a common framework across domains could help increase understanding and collaboration.** Metrics provide a means of communicating among anyone who understands their meaning. Like language, metrics may be better or only understood by certain sub-groups actively involved in their use. There is a long list of domain-specific metrics and to increase cross-domain collaboration and maximize sustainable synergies for action, more attention could be paid to “translating” the meaning of key metrics to increase shared relevance. Similarly, frameworks provide a conceptual structure to build on for research, demonstration projects, policy and other purposes. Embracing a common framework that aims to maximize the health of ecosystems and humans both could help the different domains work more collaboratively when considering issues of overlapping interest. A human “well-being” framework is one such option that incorporates human ecosystem benefit principles, articulated in the Millennium Ecosystem Assessment, as well as a broader sense of what defines human health, as initially articulated by WHO.

96. **Measuring health effects of ecosystem change considering established “exposure” threshold values helps highlight these linkages.** Mechanisms linking ecosystem change to health effects are varied, corresponding to the multitude of sub-fields within the health domain (e.g., infectious disease, occupational health, nutrition, environmental health). For many sub-fields, exposure thresholds or standards have been scientifically established that serve as trigger points *for taking action* to avoid or minimize disease or disability. For example, air quality standards exist for particle pollution, WHO has established minimum quantities of per capita water required to meet basic needs, and thresholds for food security define the quantity of food required to meet individual daily nutritional needs. Measuring the health effects of ecosystem change relative to established threshold values highlights how such change constitutes exposure – an important principle linking cause and disease or other health effects –and encourages action if thresholds are exceeded.

97. **Valuation approaches linking ecosystem functioning and health that support decisions about resource allocation may appeal to a variety of stakeholders.** Many approaches enhance understanding of ecosystem functioning and human health linkages. Common on the health side are environmental hazard or risk factor analyses. Others include identifying and reducing health disparities/inequities; focusing on environmental and socio-economic determinants of disease, and conducting health impact assessments. Conservation approaches include land-/seascape change modeling, vulnerability assessments, linked health and environmental assessments and ecosystem service analyses. Research to better quantify this relationship is undertaken by many domains and valuation processes and tools contribute to the decision-making interests of a variety of stakeholders.

98. **Tool selection depends on context and information needs, but use of comparable tools would promote a common evidence base.** Different tools exist to operationalize the different approaches to linking ecosystem functioning and health. They range from systematic assessment processes, to systematic reviews of research findings, to standardized data collection forms to computerized modeling programs. Tool choice depends on context and information needs, but more widespread use of the same or comparable tools would likely hasten development of a common evidence base, thereby increasing cross domain understanding of linkages.

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[i] Lead and contributing authors for the State of Knowldege Review on the Interlinkages between Biodiversity and Human Health include: Diarmid Campbell-Lendrum, William Karesh, Christopher Golden, Anne-Hélène Prieur-Richard, Catherine Machalaba, Johannes Sommerfeld, David Cooper, Cristina Romanelli, Marina Maiero, Daniel Buss, Bruce Cogill, Barbara Burlingame, Danny Hunter, Graham Rook, Aaron Bernstein, Suneetha Mazhenchery Subramanian, Unnikrishnan Payyappallimana, Pierre Horwitz, Conor Kretsch, Alistair Boxall, David Stone, Margot Parkes, Aaron Jenkins, Lynne Gaffikin, Peter Daszak, Christopher Allen, Colleen Burge, Piero Genovesi, Jacqueline Fletcher, Pierre Formenty, Drew Harvell, Richard Kock, Elizabeth Loh, Juan Lubroth, Kristine Smith, Peter J. Stoett, Hillary Young, Charlie Shackleton, Celine Termote, Barbara Vinceti, Phrang Roy, Harriet Kuhnlein, Bertrand Graz, Yahaya Sekagya, Eileen de Ravin, Anastasiya Timoshyna, Danna Leaman, Charlotte I.E.A. van't Klooster, Gerry Bodeker, G. Hariramamurthi, Darshan Shankar, Kahoru Kanari, Stepha McMullin, Ramni Jamnadass, Katja Kehlenbeck, Wim Hiemstra, Felipe Gomez, Rainer Bussman, David Coates, Elena Villalobos, Mariam Otmani del Barrio, Sarah Jovan, and David Nowak. Relevant experts will be invited to review the full draft of the study upon completion.