WWF Ecoregions

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1. Terrestrial Ecoregions

1.1 Deserts and xeric shrublands

Worldwide, Deserts and Xeric Shrublands vary greatly in the amount of annual rainfall they receive; generally, however, evaporation exceeds rainfall in these ecoregions, usually less than 10 inches annually. Temperature variability is also extremely diverse in these remarkable lands. Many deserts, such as the Sahara, are hot year-round but others, such as Asia's Gobi, become quite cold in winter.

Temperature extremes are a characteristic of most deserts. Searing daytime heat gives way to cold nights because there is no insulation provided by humidity and cloud cover. Not surprisingly, the diversity of climatic conditions - though quite harsh - supports a rich array of habitats. Many of these habitats are ephemeral in nature - reflecting the paucity and seasonality of available water.

Woody-stemmed shrubs and plants characterize vegetation in these regions. Above all, these plants have evolved to minimize water loss. Animal biodiversity is equally well adapted and quite diverse.

The Namib-Karoo deserts of southwestern Africa support the world's richest desert floras, while the Chihuahuan Desert and central Mexican deserts are a close second and are the richest Neotropical deserts. Australian deserts support the richest reptile faunas. The Carnavon Xeric Scrub of western Australia is a regional center of endemism for a range of taxa.

Unusual desert communities dominated by giant columnar cacti occur in the Sonoran and Baja deserts of North America, while the spiny deserts and shrublands of southwestern Madagascar are globally unique in terms of structure and taxa (although some Baja California communities are partially convergent in structure).

The Atacama Desert ecoregion of western South America (as well as the adjacent transition area of the Monte / Puna / Yungas) and the Horn of Africa deserts were recognized as some of the more outstanding regional centers of richness and endemism. The Central Asian deserts, while not nearly as rich as Afrotropical or Neotropical deserts, are representative of the region's deserts.

Biodiversity Patterns

Deserts and xeric shrublands may have extraordinarily rich floras with very high alpha and beta diversity; reptile faunas may also be very diverse; local endemism may be quite pronounced in some regions.

Minimum Requirements

Many species track seasonally variable and patchy resources and require large natural landscapes to persist; water sources and riparian habitats are critical for the persistence of many species.

Sensitivity to Disturbance

Highly sensitive to grazing, soil disturbance, burning, plowing, and other cover alteration; restoration potential can be very low and regeneration very slow; exotic species may be a serious problem.

1.2 Tropical and subtropical moist broadleaf forests

Generally found in large, discontinuous patches centered on the equatorial belt and between the Tropics of Cancer and Capricorn, Tropical and Subtropical Moist Forests (TSMF) are characterized by low variability in annual temperature and high levels of rainfall (>200 centimeter annually). Forest composition is dominated by semi-evergreen and evergreen deciduous tree species.

These trees number in the thousands and contribute to the highest levels of species diversity in any terrestrial major habitat type. In general, biodiversity is highest in the forest canopy which can be divided into five layers: overstory canopy with emergent crowns, a medium layer of canopy, lower canopy, shrub level, and finally understory.

These forests are home to more species than any other terrestrial ecosystem: Half of the world's species may live in these forests, where a square kilometer may be home to more than 1,000 tree species. These forests are found around the world, particularly in the Indo-Malayan Archipelagos, the Amazon Basin, and the African Congo. A perpetually warm, wet climate promotes more explosive plant growth than in any other environment on Earth.

A tree here may grow over 75 feet in height in just 5 years. From above, the forest appears as an unending sea of green, broken only by occasional, taller "emergent" trees. These towering emergents are the realm of hornbills, toucans, and the harpy eagle.

The canopy is home to many of the forest's animals, including apes and monkeys. Below the canopy, a lower understory hosts to snakes and big cats. The forest floor, relatively clear of undergrowth due to the thick canopy above, is prowled by other animals such as gorillas and deer.

All levels of these forests contain an unparalleled diversity of invertebrate species, including New Guinea’s unique stick insects and bird wing butterflies that can grow over one foot in length. These forests are under tremendous threat from man. Many forests are being cleared for farmland, while others are subject to large-scale commercial logging.

An area the size of Ireland is destroyed every few years, largely due to commercial logging and secondary impacts. Such activities threaten the future of these forests are the primary contributor to the extinction of 100-200 species a day on average over the next 40 years (exotics on islands and loss of island habitats are other major factors)

At the current rate of deforestation, more than 17,000 species will go extinct every year, which is more than 1,000 times the rate before man arrived on this planet.

Among the 13 terrestrial major habitat types, the largest number of ecoregions by far falls within the TSMF (50 ecoregions or 35% of all terrestrial ecoregions). The high number of ecoregions within this major habitat type reflects the biological richness and complexity of tropical moist forests.

Although there are more TSMF in the Indo-Malayan Biogeographic realm (17) than in the Neotropics (12), this is partly due to the archipelagic distributions of Asian tropical moist forests and their characteristic biotas. Four of the Asian TSMFs are small island systems, and the original extent of all of the Asian ecoregions fit easily within the area covered by western Amazonian moist forests.

The most diverse terrestrial ecoregions occur in the Western Arc forests of the Amazon Basin, with close rivals in the Atlantic Forest ecoregion of Brazil, the Chocó-Daríen ecoregion of northwestern South America, and Peninsular Malaysia and northern Borneo forest ecoregions. The montane forest biotas of the Northern Andes are remarkable for their globally high rates of beta-diversity and extraordinary local endemism.

The forests of the Guayanan region and Cuba are remarkable for their endemism and unusual biogeographic relationships. The Congolian coastal forests are likely the most diverse in the Afrotropics, although diversity information is scarce for several ecoregions in the central Congo Basin. The Guinean moist forests support many species not found in the Central African region.

The Albertine Rift montane forests are extremely rich for some taxa, such as birds, and have a high degree of endemism. The distinctiveness of the Eastern Arc Montane and East African Coastal Forests is attributable to their great age and isolation7). Madagascar forests and shrublands are also highly distinctive at global scales, even at higher taxonomic levels8). Tropical moist forests of New Guinea and New Caledonia are highly distinctive at global scales9), although Australian moist forests do share many affinities with New Guinea.

The forests of Sulawesi are noted for the regionally high degree of endemism in a range of taxa, a phenomenon also seen in the Philippines moist forests10) and in the Lesser Sundas Semi-evergreen Forests. The Western Ghats and southwestern Sri Lankan moist forests are distinctive due to their isolation and long history. Tropical moist forests on oceanic islands are often highly distinctive due to high rates of endemism, extraordinary radiations of taxa and adaptive radiation, and relictual or unique higher taxa.

Biodiversity Patterns

These habitats may display high beta diversity, particularly between isolated montane areas and along altitudinal gradients; local and regional endemism can be pronounced in some regions.

Minimum Requirements

Large natural landscapes required in some regions because larger vertebrates track widely distributed seasonal or patchy resources; water sources and riparian vegetation important for wildlife in drier regions.

Sensitivity to Disturbance

These fragile habitats are highly sensitive to plowing, overgrazing, and excessive burning due to their challenging climatic and soil conditions; larger vertebrates sensitive to even low levels of hunting.

1.3 Tropical and subtropical dry broadleaf forests

Tropical and Subtropical Dry Forests are found in southern Mexico, southeastern Africa, the Lesser Sundas, central India, Indochina, Madagascar, New Caledonia, eastern Bolivia and central Brazil, the Caribbean, valleys of the northern Andes, and along the coasts of Ecuador and Peru.

Though these forests occur in climates that are warm year-round, and may receive several hundred centimeters or rain per year, they deal with long dry seasons which last several months and vary with geographic location. These seasonal droughts have great impact on all living things in the forest.

Deciduous trees predominate these forests, and during the drought a leafless period occurs, which varies with species type. Because trees lose moisture though their leaves, the shedding of leaves allows trees such as teak and mountain ebony to conserve water during dry periods.

The newly bare trees open up the canopy layer, enabling sunlight to reach ground level and facilitate the growth of thick underbrush. Though less biologically diverse than rainforests, tropical dry forests are still home to a wide variety of wildlife including monkeys, large cats, parrots, various rodents, and ground dwelling birds. Many of these species display extraordinary adaptations to the difficult climate.

The most diverse dry forests in the world occur in southern Mexico and in the Bolivian lowlands. The dry forests of the Pacific Coast of northwestern South America support a wealth of unique species due to their isolation. The subtropical forests of Maputoland-Pondoland in southeastern Africa are diverse and support many endemics. The dry forests of central India and Indochina are notable for their diverse large vertebrate faunas. Dry forests of Madagascar and New Caledonia are also highly distinctive (pronounced endemism and a large number of relictual taxa) for a wide range of taxa and at higher taxonomic levels.

Biodiversity Patterns

Species tend to have wider ranges than moist forest species, although in some regions many species do display highly restricted ranges; most dry forest species are restricted to tropical dry forests, particularly in plants; beta diversity and alpha diversity high but typically lower than adjacent moist forests.

Minimum Requirements

Large natural areas are required to maintain larger predators and other vertebrates; large areas are also needed to buffer sensitive species from hunting pressure; the persistence of riparian forests and water sources is critical for many dry forest species; periodic fires require larger blocks of intact forest to be able to absorb

occasional large events.

Sensitivity to Disturbance

Dry forests are highly sensitive to excessive burning and deforestation; overgrazing and exotic species can also quickly alter natural communities; restoration is possible but challenging, particularly if degradation has been intense and persistent.

1.4 Tropical and suptropical coniferous forests

Found predominantly in North and Central America, these tropical regions experience low levels of precipitation and moderate variability in temperature. Tropical and Subtropical Coniferous Forests are characterized by diverse species of conifers, whose needles are adapted to deal with the variable climatic conditions.

Many migratory birds and butterflies spend winter in tropical and subtropical conifer forests. These biomes feature a thick, closed canopy which blocks light to the floor and allows little underbrush. As a result, the ground is often covered with fungi and ferns. Shrubs and small trees compose a diverse understory.

Mexico harbors the world's richest and most complex subtropical coniferous forests. The conifer forests of the Greater Antilles contain many endemics and relictual taxa. Subtropical conifer forests of Indochina are incorporated into the dry and moist forests of the region.

Biodiversity Patterns

Considerable local endemism and beta diversity occurs in some ecoregions in invertebrates, understory plants, and lichens, particularly in moister forests or on unusual soils; some larger vertebrates and dominant tree species may have widespread ranges; may have extremely floras; altitudinal specialization occurs.

Minimum Requirements

Disturbance regimes such as fire, windthrow, and epizootics can vary considerably within this major habitat type, but the extremes are typically of sufficient size and frequency as to make small patches of natural forest have only limited conservation value; many species highly specialized on late-successional forests; larger carnivores very wide-ranging with large home ranges; some species track resources that vary widely in space in time (e.g., epizootic outbreaks, fire events, cone production) requiring large natural landscapes.

Sensitivity to Disturbance

Larger carnivores highly sensitive to human activities including low intensity hunting; large number of species highly sensitive to logging and fragmentation of natural forests, particularly late-successional species; late-successional species and features typically regenerate slowly; many temperate forests require periodic fires to maintain successional processes and many species; exotic species can have extensive and significant impacts on natural forest communities.

1.5 Temperate broadleaf and mixed forests

Trees in autumn colors in Lazovsky State Nature Reserve, which is now considered one of the most important nature reserves in Russia. Boreal forest. Sikhote-Alin mountain ridge, Primorye region, Far East. Russian Federation. Forests in the temperate world experience a wide range of variability in temperature and precipitation. In regions where rainfall is broadly distributed throughout the year, deciduous trees mix with species of evergreens. Species such as oak (Quercus spp.), beech (Fagus spp.), birch (Betupa spp.), and maple (Acer spp.) typify the composition of the Temperate Broadleaf and Mixed Forests (TBMF).

Structurally, these forests are characterized by 4 layers: a canopy composed of mature full-sized dominant species and a slightly lower layer of mature trees, a shrub layer, and understory layer of grasses and other herbaceous plants. In contrast to tropical rain forests, most biodiversity is concentrated much closer to the forest floor.

TBMF are richest and most distinctive in central China and eastern North America, with some other globally distinctive ecoregions in the Caucasus, the Himalayas, southern Europe, and the Russian Far East.

Biodiversity Patterns

Most dominant species have widespread distributions, but in many ecoregions there can be a large number of ecoregional and local endemics; beta diversity can be high for plants, invertebrates, and some smaller vertebrates in some ecoregions; unusual soils can harbor many specialist plants and invertebrates; some ecoregions can have very high alpha and gamma diversity for plants, particularly understory species and herbaceous floras. Altitudinal specialization occurs but is less pronounced than in the tropics.

Minimum Requirements

Larger native carnivores require large natural landscapes to persist, periodic large-scale disturbance events such as fire necessitate the conservation of large blocks of forest; many species of plants, lichen, fungi, and invertebrates depend upon late-successional forests.

Sensitivity to Disturbance

Certain species are highly sensitive to habitat fragmentation, such as breeding songbirds exposed to parasitism or elevated nest predation; many forest understory species are also unable to cross deforested areas; restoration potential for these forests is high; exotic species can have extensive and significant impacts on native communities; the loss of large native predators has many cascading impacts on forest structure and ecology.

1.6 Temperate Coniferous Forest

Temperate evergreen forests are found predominantly in areas with warm summers and cool winters, and vary enormously in their kinds of plant life. In some,

needleleaf trees dominate, while others are home primarily to broadleaf evergreen trees or a mix of both tree types.

Temperate evergreen forests are common in the coastal areas of regions that have mild winters and heavy rainfall, or inland in drier climates or montane areas. Many species of trees inhabit these forests including pine, cedar, fir, and redwood.

The understory also contains a wide variety of herbaceous and shrub species. Temperate conifer forests sustain the highest levels of biomass in any terrestrial ecosystem and are notable for trees of massive proportions in temperate rainforest regions.

Structurally, these forests are rather simple, consisting of 2 layers generally: an overstory and understory. However, some forests may support a layer of shrubs. Pine forests support an herbaceous groundlayer that may be dominated by grasses and forbs that lend themselves to ecologically important wildfires. In contrast, the moist conditions found in temperate rain forests favor the dominance by ferns and some forbs.

Temperate rain forests only occur in 7 regions around the world - the Pacific Northwest, the Validivian forests of southwestern South America, the rain forests of New Zealand and Tasmania, the Northeastern Atlantic (small, isolated pockets in Ireland, Scotland, and Iceland), southwestern Japan, and those of the eastern Black Sea.

Forest communities dominated by huge trees (e.g., giant sequoia, Sequoiadendron gigantea; redwood, Sequoia sempervirens; mountain ash, Eucalyptus regnans), an unusual ecological phenomena, occur in western North America, southwestern South America, as well as in the Australasian region in such areas as southeastern Australia and northern New Zealand.

The Klamath-Siskiyou ecoregion of western North America harbors diverse and unusual assemblages and displays notable endemism for a number of plant and animal taxa.

Biodiversity Patterns

Most tree species and larger vertebrates have relatively widespread distributions; considerable local endemism and beta diversity occurs in some ecoregions in invertebrates, understory plants, and lichens, particularly in rain forests or on unusual soils; may have extremely diverse invertebrate faunas or herbaceous floras; altitudinal specialization occurs but is less pronounced than in the tropics.

Minimum Requirements

Disturbance regimes such as fire, windthrow, and epizootics can vary considerably within this major habitat type, but the extremes are typically of sufficient size and frequency as to make small patches of natural forest have only limited conservation value; many species highly specialized on late-successional forests; larger carnivores very wide-ranging with large home ranges; some species track resources that vary widely in space in time (e.g., epizootic outbreaks, fire events, cone production)

requiring large natural landscapes.

Sensitivity to Disturbance

Larger carnivores highly sensitive to human activities including low intensity hunting; large number of species highly sensitive to logging and fragmentation of natural forests, particularly late-successional species; late-successional species and features typically regenerate slowly; many temperate forests require periodic fires to maintain successional processes and many species; exotic species can have extensive and significant impacts on natural forest communities.

1.7 Boreal forests / Taiga

Low annual temperatures characterize northerly latitudes; precipitation ranges from 40-100 centimetres per year and may fall mainly as snow.

This combination, along with nutrient poor soils - largely a result of permafrost and the resultant poor drainage - favors the preponderence of conifer species (Abies, Picea, Larix, and Pinus), although species of deciduous trees are also rather common: Betula spp. and Populus spp. Ground cover in Boreal Forests and Taiga is dominated by mosses and lichens.

Low levels and variation of species richness and endemism are characteristic of circumboreal and circumpolar ecoregions, thus the presence of intact ecological phenomena selected outstanding ecoregions.

Large-scale migrations of caribou, or reindeer (Rangifer tarandus) and intact predator assemblages can still be found in some regions, as well as relatively unaltered natural disturbance regimes. For example, the Northern Cordillera boreal forests of Canada have been identified as the "Serengeti" of the Far North due to its abundance and diversity of large vertebrates.

Extensive tracts of boreal forest and taiga still exist in the northern Nearctic and Palearctic, the largest expanses being in central and eastern Russia.

Biodiversity Patterns

Most species tend to have widespread distributions; low alpha and beta diversity.

Minimum Requirements

Large natural landscapes of taiga are critical to maintain populations of species that track resources that vary considerably in space and time (e.g., epizootic insect events, hare irruptions), viable populations of large carnivores require extensive natural areas because of large home range sizes; disturbance events such as fire and epizootics can cover extremely large areas - even whole landscapes; fire and epizootic events required for some successional processes; large-scale linkages of natural habitat are required to permit migrations of larger vertebrates and associated predators in response to seasonal changes or disturbances.

Sensitivity to Disturbance

Regeneration of mature forests takes very long periods of time due to the challenging climate and soil conditions; many larger vertebrates are sensitive to human presence or low intensity hunting; very sensitive to acid rain and other forms of pollutants.

1.8 Tropical and subtropical grasslands, savannas and shrublands

Large expanses of land in the tropics do not receive enough rainfall to support extensive tree cover. The Tropical and Subtropical Grasslands, Savannas, and Shrublands are characterized by rainfall levels between 90-150 centimetres per year.

However, there may be great variability in soil moisture throughout the year. Grasses dominate the species composition of these ecoregions, although scattered trees may be common. Large mammals that have evolved to take advantage of the ample forage typify the biodiversity associated with these habitats.

These large mammal faunas are richest in African savannas and grasslands. The most intact assemblages currently occur in East African Acacia savannas and Zambezian savannas comprised of mosaics of miombo, mopane, and other habitats. Large-scale migration of tropical savanna herbivores, such as wildebeest (*Connochaetes taurinus*) and zebra (*Equus zebra*), are continuing to decline through habitat alteration and hunting.

They now only occur to any significant degree only in East Africa and the central Zambezian region. Much of the extraordinary abundance of Guinean and Sahelian savannas has been eliminated, although the savannas in the Sudd region are one of the last places where large-scale migrations of Ugandan Kob still occur.

Both the Cerrado and the Llanos are noted for complexity of habitats and the unusually high levels of endemism and beta diversity in plants for tropical savannas. The tropical savannas of northern Australia and southern New Guinea exhibit distinct species assemblages and higher taxa.

Biodiversity Patterns

Diverse large mammal assemblages in abundant aggregations can be a characteristic feature; most vertebrates display relatively widespread distributions; plant alpha diversity is typically low, but in some regions beta diversity and gamma diversity can be very high.

Minimum Requirements

Large natural landscapes are necessary to allow large grazers and their associated predators to track seasonal rainfall or to migrate to new areas during periodic droughts; large-scale fire events also necessitate the conservation of larger natural landscapes; some large predators, such as wild dogs of Africa, require large natural areas to persist due to home range size and sensitivity to humans; sources of water are critical for many species.

Sensitivity to Disturbance

Restoration potential in these systems is high; but plowing, overgrazing by domestic livestock, and excessive burning can quickly degrade and alter natural communities; alteration of surface water patterns can have significant impacts on the persistence of many vertebrate species; many species are highly sensitive to low intensity hunting or other human activities.

1.9 Temperate grasslands, savannas and shrublands

Known as prairies in North America, pampas in South America, veld in Southern Africa and steppe in Asia, Temperate Grasslands, Savannas, and Shrublands differ largely from tropical grasslands in the annual temperature regime as well as the types of species found here. Generally speaking, these regions are devoid of trees, except for riparian or gallery forests associated with streams and rivers.

However, some regions do support savanna conditions characterized by interspersed individuals or clusters of trees. Biodiversity in these habitats includes a number of large grazing mammals and associated predators in addition to burrowing mammals, numerous bird species, and of course, a diversity of insects.

The vast expanses of grass in North America and Eurasia once sustained vast migrations of large vertebrates such as buffalo (*Bubalus bubalis*), saiga (*Saiga tatarica*), and Tibetan antelopes (*Pantholops hodgsoni*) and kiang (*Equus hemionus*). Such extraordinary phenomena now occur only in isolated pockets, primarily in the Daurian Steppe and Tibetan Plateau (see Montane Grasslands).

The extraordinary floral communities of the Eurasian steppes and the North American Great Plains, have been largely extirpated through conversion to agriculture. Nonetheless, as many as 300 different plant species may grow on less than 3 acres of North American tallgrass prairie, which also may support more than 3 million individual insects per acre. The Patagonian Steppe and Grasslands are notable for distinctiveness at the generic and familial level in a variety of taxa.

Biodiversity Patterns

Relatively low alpha, beta, and gamma diversity, except for some exceptionally rich floras in some regions; most species have relatively widespread distributions; some larger vertebrate species may occur in great abundance.

Minimum Requirements

Many vagile species require large natural landscapes to be able to track seasonal or patchy resources, or to move from areas impacted by large-scale disturbances such as fire; the presence of water and riparian vegetation important for many species; large natural areas are needed to maintain natural fire regimes which are important for maintaining community structure and composition.

Sensitivity to Disturbance

Plowing of grasslands, savannas, and shrublands can drastically alter species compositions and the restoration potential of natural communities; excessive burning

or fire suppression can dramatically alter community structure and composition; loss and degradation of riparian or gallery forest habitats and water sources has significant impacts on wildlife; overgrazing causes significant community changes, erosion, and reduction in restoration potential; loss of keystone species such as buffalo, saiga, and prairie dogs can have major impacts on animal and plant communities.

1.10 Flooded grasslands and savannas

Common to four of the continents on Earth are large expanses or complexes of flooded grasslands. These areas support numerous plants and animals adapted to the unique hydrologic regimes and soil conditions.

Large congregations of migratory and resident waterbirds may be found in these regions.

However, the relative importance of these habitat types for these birds as well as more vagile taxa typically varies as the availability of water and productivity annually and seasonally shifts among complexes of smaller and larger wetlands throughout a region.

Some globally outstanding flooded savannas and grasslands occur in the Everglades, Pantanal, Sahelian flooded savannas, Zambezian flooded savannas, and the Sudd.
The Everglades are the world's largest rain-fed flooded grassland on a limestone substrate, and feature some 11,000 species of seed-bearing plants, 25 varieties of orchids, 300 bird species, and 150 fish species.

The Pantanal, one of the largest continental wetlands on Earth, supports over 260 species of fish, 700 birds, 90 mammals, 160 reptiles, 45 amphibians, 1,000 butterflies, and 1,600 species of plants. The flooded savannas and grasslands are generally the largest complexes in each region.

Biodiversity Patterns

Most terrestrial species have relatively widespread ranges in these habitats; alpha and beta diversity are not pronounced; endemism in terrestrial species is low.

Minimum Requirements

Maintaining hydrographic integrity is critical to these habitats; many species track flooding patterns and seasonal abundance of resources; riparian and gallery habitats are important for many species.

Sensitivity to Disturbance

Diversion and channelization of water flow greatly impact the integrity of these habitats; loss of riparian and gallery habitats can impact wildlife populations; sensitive to water quality changes from pollution and eutrophication; alteration of natural fire regimes may shift composition and structure of communities.

1.11 Montane grasslands and shrublands

This major habitat type includes high elevation (montane and alpine) grasslands and shrublands, including the puna and paramo in South America, subalpine heath in New Guinea and East Africa, steppes of the Tibetan plateaus, as well as other similar subalpine habitats around the world.

They are tropical, subtropical, and temperate. The plants and animals of tropical montane paramos display striking adaptations to cool, wet conditions and intense sunlight. Around the world, characteristic plants of these habitats display features such as rosette structures, waxy surfaces, and abundant pilosity.

The paramos of the northern Andes are the most extensive examples of this major habitat type. Although ecoregion biotas are most diverse in the Andes, these ecosystems are highly distinctive wherever they occur in the tropics. The heathlands and moorlands of East Africa (e.g., Mt. Kilimanjaro, Mt. Kenya, Rwenzori Mts.), Mt. Kinabalu of Borneo, and the Central Range of New Guinea are all limited in extent, extremely isolated, and support highly endemic plants and animals.

Drier, yet distinctive, subtropical montane grasslands, savannas, and woodlands include the Ethiopian Highlands, the Zambezian montane grasslands and woodlands, and the montane habitats of southeastern Africa.

The montane grasslands of the Tibetan Plateau still support relatively intact migrations of Tibetan antelope (Pantholops hodgsoni) and kiang, or Tibetan wild ass (Equus hemionus). A unique feature of many tropical paramos is the presence of giant rosette plants from a variety of plant families, such as Lobelia (Africa), Puya (South America), Cyathea (New Guinea), and Argyroxiphium (Hawai'i) - these plant forms can reach elevations of 4,500-4,600 meters above sea level.

Biodiversity Patterns

These habitats may display high beta diversity, particularly between isolated montane areas and along altitudinal gradients; local and regional endemism can be pronounced in some regions.

Minimum Requirements

Large natural landscapes required in some regions because larger vertebrates track widely distributed seasonal or patchy resources; water sources and riparian vegetation important for wildlife in drier regions.

Sensitivity to Disturbance

These fragile habitats are highly sensitive to plowing, overgrazing, and excessive burning due to their challenging climatic and soil conditions; larger vertebrates sensitive to even low levels of hunting.

1.12 Tundra

The tundra is a treeless polar desert found in the high latitudes in the polar regions, primarily in Alaska, Canada, Russia, Greenland, Iceland, and Scandinavia, as well as

sub-Antarctic islands. The region's long, dry winters feature months of total darkness and extremely frigid temperatures.

Structurally, the Tundra is a treeless expanse that supports communities of sedges and heaths as well as dwarf shrubs. Vegetation is generally scattered, although it can be patchy reflecting changes in soil and moisture gradients. Most precipitation falls in the form of snow during the winter while soils tend to be acidic and saturated with water where not frozen.

Tundra ecoregions were selected primarily because of extraordinary seasonal concentrations of breeding waterfowl and shorebirds, as well as caribou. Relatively intact tundra ecoregions were chosen, wherever possible. Some tundra ecoregions such as Chukotsky are distinctive in that they display an appreciable level of regional plant endemism.

Biodiversity Patterns

Species typically have widespread distributions, except for some herbaceous plants; low alpha diversity, low beta diversity.

Minimum Requirements

Vast natural habitats are required to allow many species to track patchy resources that vary in location from one year to the next (e.g., lemming irruptions), the presence of varied habitats and associated resources is critical for the survival of many vagile vertebrates; migration corridors for large vertebrates must remain intact to allow large-scale seasonal movements (e.g., caribou).

Sensitivity to Disturbance

Groundcover and surface water flow is highly sensitive to disturbance with very poor resiliency; many vertebrates highly sensitive to the presence of humans or to low intensity hunting; polar ecosystems are particularly sensitive to changes in climatic parameters associated with global climate change; toxins and other compounds tend to sequester and break down only slowly in polar ecosystems.

1.13 Mediterranean Forests, woodlands and scrubs

Mediterranean Forests, Woodlands, and Scrub ecoregions are characterized by hot and dry summers, while winters tend to be cool and moist. Most precipitation arrives during these months.

Only 5 regions in the world experience these conditions: the Mediterranean, south-central and southwestern Australia, the fynbos of southern Africa, the Chilean matorral, and the Mediterranean ecoregions of California. Although the habitat is globally rare, it features an extraordinary biodiversity of uniquely adapted animal and plant species, which can adapt to the stressful conditions of long, hot summers with little rain. Most plants are fire adapted, and dependent on this disturbance for their persistence.

All 5 Mediterranean-climate ecoregions are highly distinctive, collectively harboring 10% of the Earth’s plant species. Phytogeographers consider the Fynbos as a separate

floral kingdom because 68% of the 8,600 vascular plant species crowded into its 90,000 kilometer2 are endemic and highly distinctive at several taxonomic levels.

In terms of species densities, this is equivalent to about 40% of the plant species of the United States and Canada combined, found within an area the size of the state of Maine (N. Myers, pers. comm.). The Fynbos and Southwest Australia shrublands have floras that are significantly more diverse than the other ecoregions, although any Mediterranean shrubland is still rich in species and endemics relative to other non-forest ecoregions.

Biodiversity Patterns

Regional and local endemism is common, with some species with highly restricted ranges; high alpha and very high beta diversity, particularly in plants; specialization on soils is common.

Minimum Requirements

Blocks of natural habitat need to be large enough to sustain regular fire events such that unburned patches are left to act as source pools and refugia for vagile species; some species undertake seasonal movements in response to resource availability, thus diverse habitats and natural linkage habitats are important; riparian habitats critical for survival of many species.

Sensitivity to Disturbance

Natural communities are highly sensitive to habitat fragmentation, grazing, and alteration of fire regimes (overburning or fire suppression), native species are particularly at risk from exotic plants and animals that establish and spread with ease in these communities; restoration of communities is feasible but fire regimes must be restored and exotics controlled effectively

1.14 Mangroves

Mangroves occur in the waterlogged, salty soils of sheltered tropical and subtropical shores. They are subject to the twice-daily ebb and flow of tides, fortnightly spring and neap tides, and seasonal weather fluctuations. They stretch from the intertidal zone up to the high-tide mark. These forests are comprised of 12 genera comprising about 60 species of salt-tolerant trees.

With their distinctive nest of stilt and prop-like roots, mangroves can thrive in areas of soft, waterlogged, and oxygen-poor soil by using aerial and even horizontal roots to gain a foothold. The roots also absorb oxygen from the air, while the tree's leaves can excrete excess salt.

Associated with the tree species are a whole host of aquatic and salt-tolerant plants. Together they provide important nursery habitats for a vast array of aquatic animal species.

Mangrove ecosystems are most diverse in South Asian seas and least diverse in the Caribbean. Mangrove forests on the western coast of Madagascar support a number of endemic bird species that are endangered. In some tropical countries, such as India,

the Philippines, and Vietnam, over 50% of mangrove ecosystems have been lost in this century.

Biodiversity Patterns

Most species typically have relatively widespread distributions; low diversity floras but overall alpha diversity very high when terrestrial and aquatic species are considered; very low beta diversity and low ecoregional endemism; some highly localized species exist; strong zonation along gradients; several distinct mangrove habitat formations.

Minimum Requirements

Mangroves require relatively intact hydrographic and salinity regimes, without these conditions remaining within natural ranges the persistence or restoration of mangroves is difficult or impossible.

Sensitivity to Disturbance

Alterations of hydrography and substrate have considerable impact, but restoration potential is high; mangroves are susceptible to pollution, particularly oil and other petroleum compounds; alteration of salinity levels can have dramatic impacts on mangroves.

2. Freshwater Ecoregions

2.1 Large river ecosystems

Faunas adapted to high flow regimes of large rivers are uncommon and best developed in the Yangtze, Colorado, lower Mississippi, and lower Congo rivers. A relatively small area of rapids in the latter region supports 22 endemic species of rapid specialist fish.

The Mekong, Congo, Paranáand Amazon-Orinoco Rivers harbour the 4 great large tropical river fish faunas2). The waters of the Lower Mississippi River contain outstanding examples of large river fishes, amphibians, reptiles, and invertebrates, including glacial relicts and many endemics.

2.2 Large river headwater ecosystems

Species, assemblages, and processes in headwater areas are distinct from those of their larger mainstems.

The Mississippi Piedmont, Guayanan highlands, Upper Amazon, Upper Paraná, Brazilian Shield, Congo Basin Piedmont harbor a tremendous array of species, including numerous endemics adapted to life in these waters. In turn, these river systems ultimately feed a number of the world's largest and richest rivers.

2.3 Large river delta ecosystems

Delta complexes of several large temperate and polar rivers are identified, including the Mesopotamian, Volga, and Lena river deltas. The Niger, the most extensive river delta in Africa, is characterized by high species richness. The extensive deltas of the Orinoco and Amazon rivers are covered by their respective large river ecoregions.

2.4 Small river ecosystems

The Mississippi River embayment, the Mobile River basin, and numerous coastal streams and rivers of southeastern North America together support one of the Earth's richest temperate freshwater biotas.

The headwater streams and rivers of the Yangtze River in central China are also extremely diverse (recognized as a large river major habitat type in this analysis). Secondary centers of temperate diversity occur in the rivers and streams of southeastern North America, the western coast of North America, and the Russian Far East.

Several freshwater biotas on islands are highly distinctive, including those of Madagascar, New Guinea, the Greater Sundas, the Greater Antilles, Sri Lanka, and New Caledonia. The Southwest Australian Rivers and streams ecoregion is a center of endemism, while also harboring a number of primitive higher taxa and several species with highly unusual freshwater life histories.

Rivers and streams along the Gulf of Guinea harbor some of the richest and most endemic riverine freshwater biotas in Africa. The Salween River that flows from China to Myanmar is recognized for its rich and endemic freshwater fish fauna.

2.5 Large lake ecosystems

The Global Ecoregions also identify the most outstanding examples of diverse and endemic freshwater faunas in large lakes found in temperate and tropical regions, many displaying extraordinary species flocks and adaptive radiations in fish taxa.

Some particularly notable lake biotas include those of the African Rift Lakes and Lake Tana in Ethiopia, Lake Baikal, Lake Biwa of southern Japan, the high altitude lakes of the Andes, and the highland lakes of Mexico.

2.6 Small Lake Ecosystems

Similarly, a number of lentic systems represented smaller lakes around the world host extraordinary expressions of freshwater biodiversity.

Lake Kutubu of New Guinea, Yunnan Lakes &Streams, Mexican Highland Lakes, the Cameroon Crater Lakes, Lake Lanao of the Philippines, Lake Inle in Myanmar, and Central Sulawesi Lakes have been selected for their globally outstanding biodiversity features.

2.7 Xeric basin ecosystems

Little permanent surface water and a relative abundance of springs characterize ecoregions in this major habitat type. Extraordinary freshwater biodiversity in desert regions occurs in the Chihuahuan, Anatolian, and Central Australian freshwater ecoregions.

The Cuatro Ciénegas spring and pool complex in the Chihuahuan Desert is unique in its high richness, extreme endemism, and unusual evolutionary adaptations. As well, rivers in the Anatolian region of Turkey support many endemic species adapted to these waters.

3. Marine Ecoregions

3.1 Polar Ecoregions

Low temperatures, low salinity, high plankton levels and correspondingly green color generally characterize Polar marine waters. Extensive ice is also typical of the polar ocean, both in terms of cover by sheets and in the form of drift ice and icebergs carried by polar currents.

Ice provides important habitat in the form of breeding platforms from which seals breed and search for food. Polar bears in the Arctic, and penguins in the Antarctic, also rely on the ice for habitat. Species diversity is enhanced in the Polar seas by a system of warm water upwellings that create breaks in the ice. The corresponding open areas support numerous invertebrates, fish, sea birds, and marine mammals - the result of a broad based food chain.

The Weddell Sea and Peninsular Antarctica were identified as the most productive and diverse ecoregions of the Antarctic large marine ecosystem, while the Bering, Beaufort, & Chukchi Seas and Barents Sea ecoregions are arguably 2 two most diverse and productive Arctic marine ecosystems.

3.2 Temperate Shelf and seas ecoregions

The Temperate Shelf and Seas are highly productive regions of great biological importance, supporting resident as well as migratory species during various life cycle stages. The relative shallowness of these regions (the continental shelf extends to an average maximum depth of 150 meters) leads to warmer temperatures and seasonal stratification of the water column based on temperature.

Seasonal variability, along with freshwater influxes from coastal streams and tidal action, contribute to very heterogeneous habitats and a correspondingly high diversity of organisms: fish, invertebrates (productive benthic communities), marine mammals, and numerous marine bird species.

Some of the most productive marine ecosystems occur in the Grand Banks and New Zealand plus the Patagonia ecoregions. The South Australian coastal waters are remarkable for unusually high levels of endemism in invertebrates, in addition to the diverse marine mammal assemblage found there.

Two of the world's largest temperate estuaries, the Chesapeake and Delaware Bays and the Northeast Atlantic Shelf are elevated to the Global Ecoregions due to their size, productivity, and habitat diversity. Two of the most distinctive enclosed temperate seas, the Mediterranean Sea and the Yellow and East China Seas, are recognized in the Global Ecoregions.

3.3 Temperate Upwelling

Important coastal upwelling areas occur along the West Coast of North America where the California Current moves southward. Along the Southwest coast of Africa the Benguela Current exhibits similar dynamics.

Temperate Upwelling regions are continental margins characterized by the consistent welling up of nutrient rich bottom waters to the surface. These regions are remarkably productive and are associated with large fisheries and correspondingly large populations of seabirds. Fish populations are generally enormous, schooling, and characterized by great amounts of biomass but relatively few species of small fish (e.g., the Peruvian anchovetta).

The high productivity in Temperate Upwelling regions is based on large quantities of low diversity phytoplankton communities that support short, relatively uncomplicated food chains. Species diversity is variable and often includes species entrained from deep upwelled water. These regions are largely characterized by low precipitation, and adjacent terrestrial ecoregions are often arid.

3.4 Tropical Upwellings

Similar to Temperate Upwelling areas, Tropical Upwelling habitats are characterized by high productivity resulting from the upwelling of nutrient rich bottom waters. These regions are distinct from other tropical waters in that the bottom waters bring cool water and nutrients to the surface.

Contrasted with the warm, highly saline, and nutrient poor waters typical of tropical marine ecosystems, Tropical Upwelling habitats support distinctive species and systems. The combination of high productivity and tropical climates produce unique communities that often support a high level of endemism as well as high levels of productivity. Large numbers of fish and sea birds are found here, as are a diversity of sea turtles and marine mammals.

The Humboldt Current along the West Coast of South America and the Canary Current along the West Coast of Africa bring rich nutrients to the sea surface where they support highly productive marine systems. In addition, important tropical upwelling and current areas occur in the Panama Bight ecoregions.

3.5 Tropical Coral

The greatest known species diversity of any marine ecosystem is found in coral reefs; their vertical growth and complexity provides numerous niches for different species to fill.

In addition to the calcium carbonate structure that the diverse corals species provide, numerous species of attached sponges and algae help to give the reefs their form. Tropical Coral reefs are fragile and diverse habitats that exist in sunlit waters along continental and island margins, with diversity greatest near the Equator.

Southeast Asian seas support over 450 species of scleractinian corals, the western Indian Ocean around 200, and the Caribbean only 50 species. Variation in reef fish and non-coral invertebrate diversity follows a similar biogeographic pattern. Overall, the coral reef communities of Southeast Asian seas are the most diverse in the world, with the Sulu, Sulawesi, Banda, and Coral sea ecoregions being the most diverse on Earth.

The largest barrier reef in the world is the Great Barrier Reef. Other world-class barrier reefs include the barrier reefs of New Caledonia, the Mesoamerican barrier reef, and the large barrier reefs of Fiji. The largest coral atoll complexes occur in the Maldive-Lakshadweep ecoregion of the central Indian Ocean and in Micronesia.