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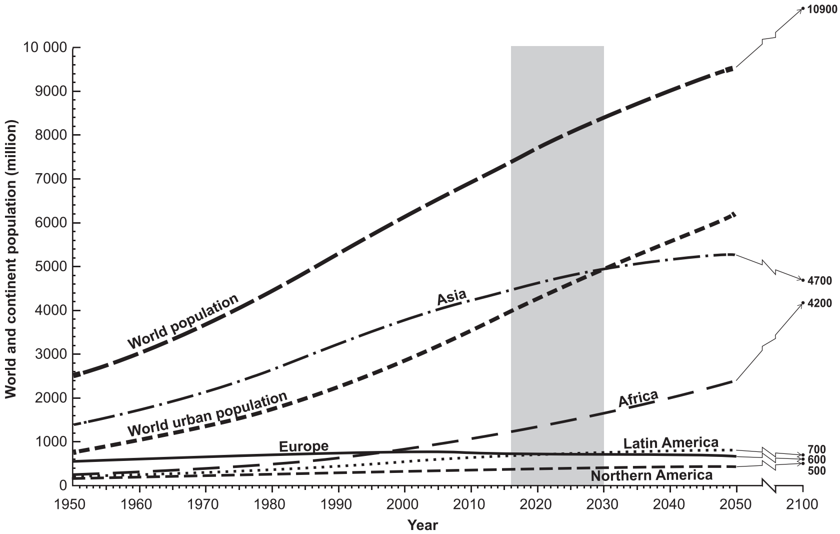
19. Where are the best places for the next billion people? Think globally, plan regionally*

Richard T.T. Forman and Jianguo (Jingle) Wu

19.1 FOUNDATIONS

19.1.1 Global Population Trends and the Next Billion

The United Nations recently projected that the world population will increase to 9.6 billion in 2050 and 10.9 billion in 2100, with a continuing upward trend (Figure 19.1) (Gerland et al., 2014; but see Lutz et al., 2008). This new forecast overturns the widely accepted projection in the literature during the past 20 years that the global population will stabilize at about 9 billion by the end of this century (e.g., Lutz et al., 2008). The world population increased from 6 billion in 1999 to 7 billion in 2012,



Source: United Nations (2013).

Figure 19.1 Population growth of world, urban areas, and continents and is expected to reach 8.1 billion by 2025 (United Nations, 2013). Based on UN projections, there will be an increase of approximately 1 billion people in 14 years, for example, 1.02 billion from 2016 to 2030 (Figure 19.1).

Future population growth will be quite uneven geographically, with almost all future growth likely occurring in Africa and Asia (Figure 19.1). By 2050, the Asian population is expected to peak and then decline, whereas the African population will continue to soar. Excluding small nations (< 50 000 km^2), nearly all African and Middle Eastern nations currently have a high annual population growth (> 2 percent), and European and North American nations a low growth rate (< 1 percent) (World Bank, 2015). In contrast, many Latin American and Asian (including Oceania) nations have low growth rates, but medium and high growth rates are also present, producing a patchy pattern within these continents.

Future global trends are characterized by declining fertility and growth rates, increased aging populations (especially in developed nations), rapid urbanization, increasing transnational migration (from developing to developed countries), and accelerated environmental deterioration (air, water and soil pollution, plus land degradation) (Lutz et al., 2008; Harper, 2014). Almost all future population growth is expected to be urban (see Figure 19.1), though dispersed growth in rural areas may occur (Kotkin, 2010). In 2014, 54 percent of the world's population was urban, and 66 percent urban is anticipated in 2050 (United Nations, 2014). By 2050, the urbanization level is projected to reach 64 percent for Asia and 56 percent for Africa.

Imagine the entire world population urbanized by 2092 (Batty, 2011) with everyone living in an urban area. The rapid urbanization of the planet Earth, particularly in its dry and resource-poor regions, implies myriad environmental, economic, and social challenges to humankind in the coming decades. Cities must be a major focus of sustainability science and practice, if both people and nature are to thrive long term (Forman, 2008; Wu, 2013, 2014).

19.1.2 Key Global Issues Changing Along with Population

The area of land (and water) needed to provide energy and material resources consumed, and absorb the wastes discharged, for a population is referred to as the ecological footprint (Wackernagel and Rees, 1996). Human demands for ecosystem goods have apparently exceeded the Earth's regenerative capacity since the 1980s, overshooting the global biocapacity by 20 percent in 1999 (Wackernagel et al., 2002). Therefore, adding a billion people will certainly further degrade our finite planet. In effect, the best or most suitable places for major population growth are 'least bad'. To reduce the future environmental and human crises puts a premium on protecting and improving farmland, natural land and built areas.

Cities have been a major focus of footprint analysis because of their rapidly escalating environmental impacts near and far. For example, the ecological footprint of Vancouver in 1991 was estimated as 200 times the geographic area of the city (Rees, 1997). The footprint of the 29 cities in Baltic Europe was at least 565 to 1130 times the total area of the cities themselves (Folke et al., 1997). Large US cities also have an ecological footprint a few hundred times larger than their physical size (Luck et al., 2001). Shrinking the ecological footprint of a city population to the urban region makes sense as a policy goal. Meanwhile, localizing the area of resources consumed and wastes discharged near a city not only reduces transportation costs, but also enables people to see and live with their environmental effects.

The projected global population growth (see Figure 19.1) is associated with, and will catalyze, other major environmental, human and spatial changes. Consider shortages of clean freshwater, air and water pollution, food shortages, natural habitat loss and degradation, rapid outward urbanization, movements of people and climate change effects. Currently these are major problems in many of the world's cities and regions (Hardoy et al., 2001; McGranahan and Satterthwaite, 2003). Before identifying more suitable places for major population growth, we briefly highlight global freshwater availability, followed by urban region characteristics.

19.1.3 Freshwater Availability

Increasingly a global characteristic, water shortages are most severe in the world's vast drylands. These areas normally have low precipitation, high climatic variability, infertile soils and slow economic development. Drylands cover 41 percent of the ice-free land area of the Earth, and support > 38 percent of the global population (Millennium Ecosystem Assessment, 2005; Reynolds et al., 2007). About 90 percent of the dryland population resides in developing countries, with an average GDP per capita 30 percent lower than the global average. Making things worse, climate models predict that most drylands will become drier with more frequent extreme weather and climatic events (IPCC, 2013).

Water use has been increasing twice as fast as world population, and 'By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could live under water stress conditions' (UN, 2015). Providing acceptable-quality water for people long term, without devastating ecosystem functions and biodiversity, is a huge challenge. Thus freshwater supply is considered a primary constraint on where the best places are globally and regionally for the next billion people.

19.1.4 The Urban Region

Many big problems are especially visible to urban residents (Hardoy et al., 2001; McGranahan and Satterthwaite, 2003), including heat and flooding associated with widespread impervious surface; everything bathed in human-distributed chemicals and wastes; water systems massively disrupted, polluted and truncated; farmland altered and abandoned; and natural ecosystems extensively lost, degraded and fragmented. These correlate with population growth. Yet, without changing the amounts of these attributes, their negative effects can be significantly reduced by creating wise spatial arrangements around cities (Alberti and Marzluff, 2004; Forman, 2008, 2014; Ahern, 2013).

A functional urban region concept highlights the area of active two-way interactions between a city and its surroundings (Forman, 2008). Often with a radius of some 70–100 km or more, and unlike a city, an urban region is especially suitable for urban or land use planning to reduce the ecological footprint and promote sustainability.

Think globally, plan regionally, and then act locally. At the global scale, focus sustainability efforts on dryland regions, less-developed regions (especially Africa and Asia), and rapidly urbanizing regions. On local and regional scales of village, town, city and region, minimize the amount, and increase the efficiency, of resource use; better design and plan landscapes; and rediscover and invent more sustainable ways of living, working and playing.

We now sequentially highlight: (1) best places globally/continentally for the next billion people; (2) best places in urban regions for major population growth; and (3) strategies for improving farmland, natural land, and built areas.

19.2 BEST PLACES GLOBALLY FOR THE NEXT BILLION PEOPLE

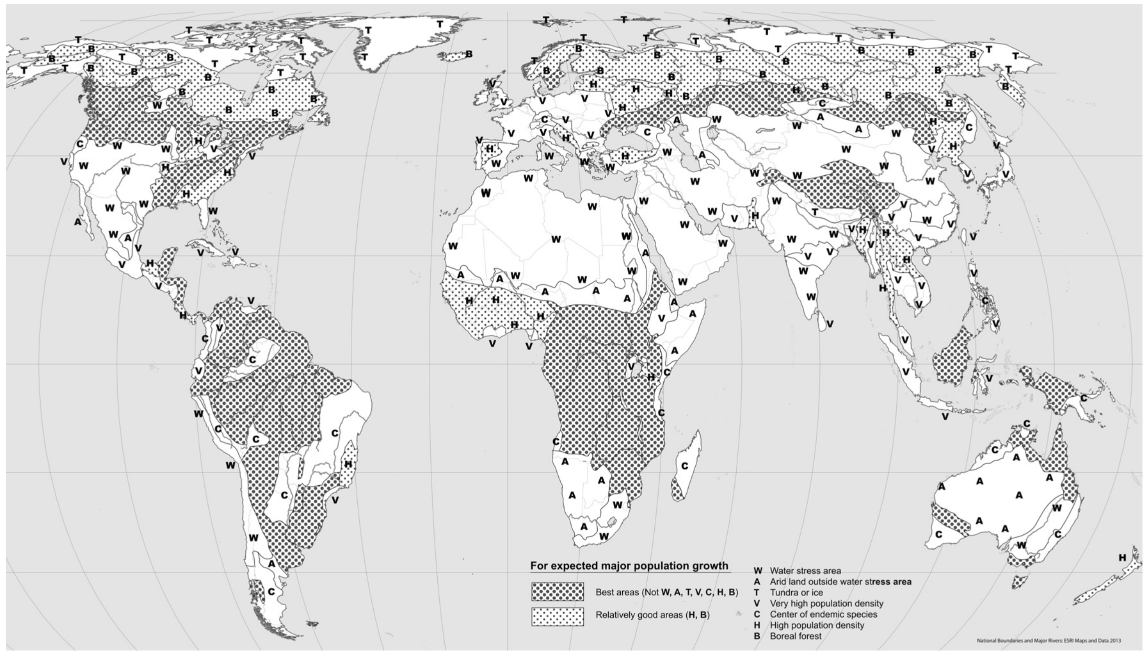
For consistency in this global and continental analysis, we used information and maps for diverse variables from the *Atlas of Global Conservation* (Hoekstra et al., 2010). Highlighting the importance of environmental constraints and existing population density, we began by excluding water-stressed regions (similar to UNEP, 2008) as inappropriate for major population growth. Other arid areas (including deserts and desertified areas) were next excluded, followed by tundra-and-ice areas. Very high-density population areas not already marked out were then excluded. Similarly, centers of endemic species, high-density population areas, and boreal forest were sequentially excluded. Centers of endemic species highlight the importance of biodiversity (many other 'hotspots' of species exist). We have not added socio-economic and other variables such as availability of jobs, quality of government, conflict areas, or deforestation, since these often evolve with the environmental and population-density constraints and fluctuate at shorter time scales.

The best areas for major population growth on the global/continental scales are those remaining after excluding the preceding seven variables (Figure 19.2). Thus the most suitable areas for the next billion people are in well-watered warm regions: (1) large areas of South America; (2) areas of southern Canada and northern and eastern USA; (3) south-central Africa; (4) Asia north of the Himalayas and in a west-to-east strip from the Black Sea to North China; and (5) scattered areas in Oceania.

A second category of areas with somewhat less severe constraints may be considered slightly less suitable areas for growth. These are the high-density population and boreal forest areas (Figure 19.2): (1) central Canada; (2) West Africa; (3) wide west-to-east strip from Scandinavia to Kamchatka; (4) northeastern China; and (5) half of Southeast Asia.

A striking disconnect emerges. The most suitable areas globally (Figure 19.2), especially those characterized by relatively satisfactory freshwater availability, differ markedly from the areas (see Figure 19.1) projected to grow rapidly in population in the decades ahead. This seems to imply that transnational migration pressure from high-growth population to 'best place' high-resource areas (see Figures 19.1 and 19.2) will be evident in the decades ahead.

Migration of tens or hundreds of thousands (but normally not millions) of people has been driven by disease, religion, ideology, space, war and more, and may now be increasingly spurred by spreading water stress. Although migration between cities and regions within a nation is widespread, overwhelmingly people remain residents of their nation. Transnational migration, rather than promising a sustainability solution (Tanton, 1994), commonly poses significant problems for a source area, the travel route, and the recipient, usually urban, region.



Note: Water stress indicates that freshwater withdrawal exceeds human requirements (UNEP, 2008); only extreme and high water-stress areas included. Very high-density population area = > 100 people/km^2; high-density population = 50–100/km^2. Center of endemic species = high concentration of bird, mammal, reptile and/or plant species unique to a region. See text.

Source: Based on Hoekstra et al. (2010); ESRI 2013 base map.

Figure 19.2 Proposed most suitable areas globally for major population growth based on environmental and population constraints

19.3 BEST PLACES IN URBAN REGIONS FOR THE NEXT BILLION PEOPLE

19.3.1 Spatial Options

Most cities began where good agricultural soil was near a water body and natural land. Thus over the years, typically outward urbanization has covered valuable soil, polluted local water bodies and eliminated the nearest natural lands.

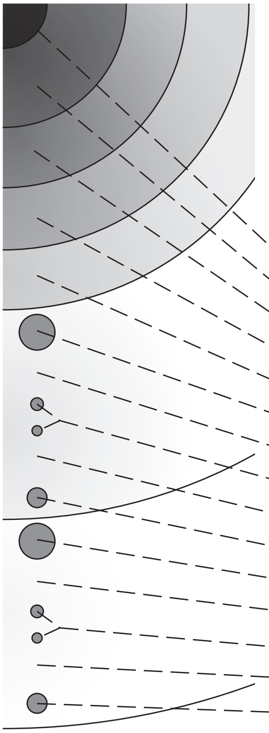
Fifteen types of places in an urban region are identified where major population growth could be concentrated (Figure 19.3). For each, the effects on both total area and highest quality of (1) food-producing land, and of (2) natural land that would be eliminated and/or degraded are estimated. The results suggest that the best places (least damaging to farmland and/or natural land) for major population growth are (Figure 19.3): city center; ring immediately around city center; inner and outer suburbs; and within satellite cities in either farmland or natural land.

The worst places (most damaging) appear to be areas surrounding satellite cities, areas surrounding towns/villages and a newly built city/town, again in either farmland or natural land (Figure 19.3). Exurban sprawl areas and towns/villages in farmland emerge as intermediate in suitability. In farmland, any focused development, except within satellite cities and towns/villages, is likely to noticeably degrade food production capacity. In natural land, any major development outside satellite cities can be expected to seriously erode ecosystem values and services.

However, space available for major population growth must be considered. Overall, space availability for the best and intermediate suitability places (Figure 19.3) is:

City center	0	None
Ring around city center	X	Little
Inner suburbs	X	Little
Outer (almost all-built) suburbs	XX	Medium
Exurban sprawl area	XXX	Extensive
Satellite cities (in farmland or natural land)	XX	Medium
Towns/villages in farmland	XXX	Extensive

Thus, combining the Figure 19.3 results with space availability suggests that the best, or least problematic, places to focus population growth are: (1) outer suburbs; (2) exurban sprawl areas; (3) satellite cities; and (4) towns/villages in farmland. Importantly, this assumes urban region



○ = None; X = Little; XX = Medium; XXX = Extensive

Place where major population growth might occur or be targeted		Amount of area eliminated and/or degraded: Food-producing land – Total area	Food-producing land – Highest quality	Natural land – Total area	Natural land – Highest quality
City center	(C)	○	○	○	○
Ring immediately around city center	(C)	○	○	○	○
Inner suburbs	(D)	○	○	○	○
Outer suburban area almost all-built	(D)	X	○	X	○
Exurban sprawl area	(D)	X	X	X	X
Satellite city in farmland	(C)	○	○	X	○
Area surrounding farmland satellite city	(D)	XX	XX	X	X
Towns/villages in farmland	(C)	X	X	X	○
Area surrounding farmland towns/villages	(D)	XXX	XXX	X	X
New city/town built in farmland	(C)	XX	XXX	X	X
Satellite city in natural land	(C)	○	○	X	○
Area surrounding natural-land satellite	(D)	X	X	XXX	XX
Towns/villages in natural land	(C)	○	○	X	XX
Area surrounding natural-land towns/villages	(D)	X	X	XXX	XX
New city/town built in natural land	(C)	○	○	XXX	XXX

Note: Farmland is mostly active and fallow cropland; natural land (forest, woodland, grassland, or desert) includes semi-natural land. Total area refers to food-producing or natural land in a city's urban region. Highest-quality food-producing land is mainly minimally polluted high-quality agricultural soil, or a large relatively intact agricultural area. Highest-quality natural lands are large natural areas (including large semi-natural patches in farmland), major water bodies, and vegetation strips alongside water bodies. The ring immediately around city center is often characterized by former or old industry, mixed use, scarcity of parkland and rapid change. We assume typical characteristics: villages, towns and cities developed where good agricultural soil and a surface water body are in proximity; farmland contains some surface water bodies and patches of semi-natural vegetation; and relatively contiguous natural land and surface water bodies are present in the outer portion of the urban region (Forman, 2008). C = concentrated in; D = dispersed across.

Figure 19.3 Possible places for major population growth in an urban region, with estimated effects on food-producing land and natural land

planning, and that growth locations fit effectively within the plan outlined. Below we look more closely at key issues to consider in the rapidly changing areas beyond the inner suburbs. Rapid change represents opportunity, a time to improve trajectories.

BOX 19.1 URBANIZATION/SETTLEMENT AROUND AFRICAN CITIES AND A RURAL AREA

Landscape transformation processes over 23 years (1986–2009) were studied in and around four cities of four nations in dry Sub-Saharan West Africa (Brinkmann et al., 2012). The 2009 populations of Kano, Niamey, Sikasso and Bobo-Dioulasso varied from 160 000 to 2.3 million, and all had intensive urban production of vegetables. During the period, woodland and shrubland were eliminated, cropland > 10 km from city edge expanded (associated with irrigation in two cases), and then cropland changed to barren land and was abandoned. Also, built area urbanization spread, but the population grew much faster, creating rapid densification. Urbanization expanded from the edge of cities, but also increased in small towns within 25 km of the city center. In two cases urbanization was concentrated by water and roads, while in two cases it was further away from them.

In Kenya, major settlement and progressive population growth occurred in a remote area by a national park with large wildlife populations (Muriuki et al., 2011). The villages began next to woodlands. Small woodland patches were removed first for firewood and home uses, so patch number rapidly decreased and average size increased. Larger wooded patches then became more open and shrank in size during charcoal production. Small, cultivated patches continued to increase in number (to approx. 300). They then coalesced into five large subsistence farming areas subject to wind/water erosion. In addition to farmland, wildlife, biodiversity and natural systems were severely degraded by this changing land mosaic spatial pattern associated with population growth.

19.3.2 Primary Outward Urbanization Patterns

Four basic models describe outward urbanization worldwide: bulges (from a city border), satellite cities growth, dispersed sites sprawl, and transportation corridor (strip/ribbon) development (Forman, 2008, 2014). The first two emerge as better environmentally, the last two worse. Each city or region portrays its own combination of the patterns. The greatest population growth is projected for Africa (see Figure 19.1), yet today's urbanization patterns there seem to seriously degrade both farmland and natural land (Box 19.1).

Elsewhere, bulge expansion, which only adds groups of buildings next to existing buildings, minimizes degradation of food-producing and natural lands, and may enhance communities. Outside Rome over 40 years (1960–2000), cropland, vineyard/orchard, and woodland each dropped by about a third, as low-density housing tripled in area (Salvati et al., 2012). Yet, in addition to sprawl, towns tripled in building density. Outside Dongguan (South China) over 18 years (1988–2006), initial urbanization was both expansion from the city edge and dispersed 'leapfrog' development (Liu et al., 2010).

Over time, leapfrog growth sharply dropped, infilling rapidly increased and edge expansion remained high throughout. Around diverse USA cities long-term settlement patterns seemed to occur in four patterns (Clark et al., 2009): clustered growth adjoining a city; clustered growth separated from the city; dispersed growth; and linear growth. Commonly a city showed two of the patterns. Finally, recent studies suggest that cities worldwide are becoming increasingly complex in their landscape structure with increasing diversity of land use types, edge density (total boundary length between land uses) and patchwork geometry (Jenerette and Potere, 2010; Wu, 2014).

Spatial urbanization patterns affect sustainability on the scale of cities and urban regions (Borrego et al., 2006; Jabareen, 2006; Bereitschaft and Debbage, 2013). Cities with compact forms, high population densities, interstitial green spaces, and houses with small yards are likely to have low per-capita ecological footprints (Jabareen, 2006; Sushinsky et al., 2013). At the regional scale, protecting farmland and natural areas, and maximizing landscape connectivity of green and blue spaces, minimizes the overall environmental impacts of urbanization (Forman, 2008; Lin and Fuller, 2013; Wu, 2014).

Now we turn to practical solutions for improving food-producing land, natural land and communities. Rather than mainly global prescriptions and policies, such as more crop genetics, harvesting marine plankton, doubling of protected land or building only multi-unit housing, we highlight a more place-based focus, where existing and future people will live and work.

19.4 IMPROVING FARMLAND

High-quality agricultural soils, normally with ample water, mineral nutrients and organic matter, are prime for food production, especially in large contiguous areas and with minimal pollutants added. Protection of these areas from urbanization, fragmentation and industrial pollution, plus improvement, remains a priority to feed the rapidly growing world population.

19.4.1 In Urban Regions

An array of urban region solutions will improve food-producing land despite a new billion people:

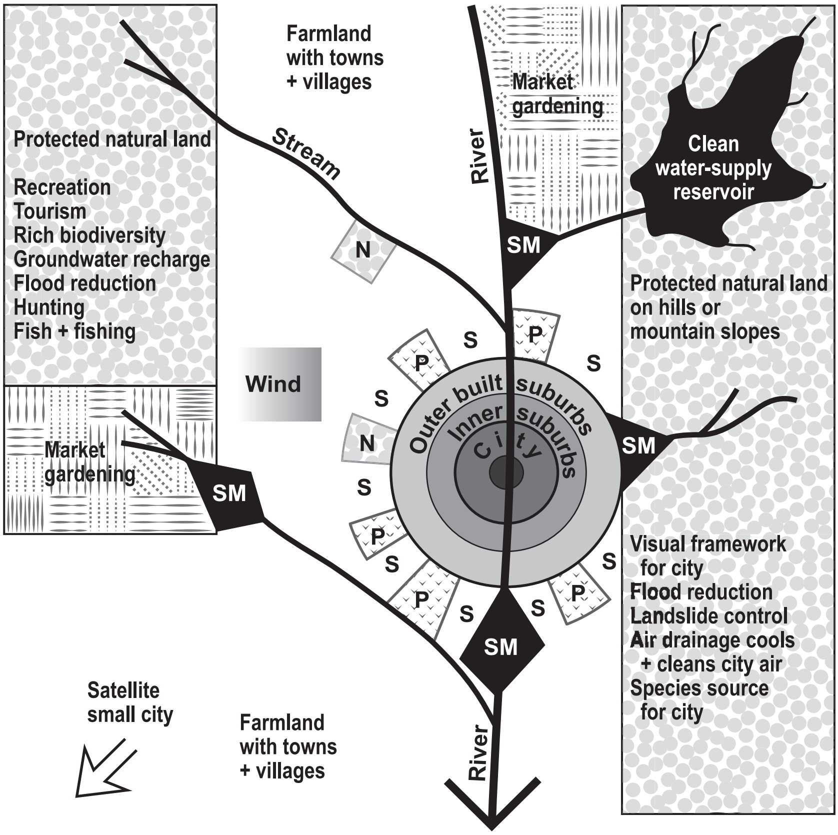
Prevent or minimize development on the best soils, thus providing food and stability for the future. Use these best soils relatively near cities mainly for vegetable and fruit production, supplemented by other crops, but not for livestock production. Clean water, biodiversity and recreational benefits are added by strategically locating bits of nature across farmland. Flooding is reduced with natural vegetation covering small headwater streams and intermittent channels. Outside Barcelona, avian diversity, especially rare species, is negatively related to both forest area (mostly fragmented) and built area, but positively correlated with cropland and with shrubland-grassland (Santos et al., 2008). Mosaic areas of woodland, cropland, and built area are especially rich in species.

Establish with a strong legal framework at least two large 'market gardening' (truck farming) areas of good soil, preferably on a floodplain or with irrigation (Figure 19.4). These strategic highly productive areas of mainly perishable vegetables and fruits readily transported at minimal cost, provide fresh produce to city markets and restaurants. With two or more market gardening areas providing flexibility and stability, they also help provide relatively clean moist cool air for the city. Urban social benefits are also evident, including farming families and employees providing diversity, urban community groups growing food, and food provided for needy low-income city residents.

To avoid contamination of these best soils, and hence the foods produced, nearby and upwind polluting industries, incinerators, and power plants are prohibited or moved. Analogously, to sustain quality soils long term, agricultural chemical use is limited. Modern industrial centers are established elsewhere with economically efficient power, water, transportation resources and waste disposal, where older and poorly located industries can relocate, and new industries can invest. Often this process helps clean up local water bodies. Also, research and pilot projects using urban wastewater aquaculture to produce clean food, consistent with public health and clean water constraints, warrant acceleration.

At a finer scale, urban agriculture within a city includes growing food in window boxes/balconies, home vegetable gardens, community gardens, rooftops and so forth. Impressive results, especially for vegetables in many African cities, are documented worldwide (Forman, 2014). Results can be quickly achieved as, when the Soviet Union terminated subsidies, Cuban urban agricultural production skyrocketed.

Street trees, parks and other public spaces can also produce a range of usable products such as fruits, nuts and fiber (Clark and Nicholas, 2013). Thus urban region food production, urban agriculture and urban food forestry are a key to urban sustainability or resilience. Not only securing food supply, they also decrease energy use and greenhouse gas emission, reduce the global spread of infectious diseases, enhance physical and mental health (Reeves, 2014), and help maintain the social-environmental identity and diversity in cities.



Note: An urban area (in moist climate, typically ringed by farmland, with woodland beyond) includes: city, with city center and ring immediately around it; suburbs, both inner and outer, and almost all-built; and sprawl area, with low population density and scattered developments. The highest-priority natural systems areas are highlighted; see text for their primary values and uses. P = park, which includes intensive recreational use; N = patch of semi-natural vegetation; S = sprawl area; SM = stormwater mitigation area.

Figure 19.4 Diagrammatic model to sustain ecosystem services for cities

19.4.2 Agricultural Land Worldwide

With noticeably more people, plus existing food shortages, greatly increasing the number of major food species and varieties makes good sense. This builds on the familiar ecological principle of each species using a somewhat different set of environmental resources. Drought-tolerant food species for expanding drylands are especially needed.

Many productive annual grains are potentially replaced by perennial grains, which greatly decreases soil degradation and erosion and minimizes the use of machinery and fossil fuel (Jackson, 1980; Cox et al., 2006; Pimentel et al., 2012). For instance, a mosaic with large areas of perennials and small areas of annuals may be effective in many semiarid and mesic regions.

Some 30 percent of the non-ice-covered land is used for livestock production. Consistent with the second law of thermodynamics, it takes a lot of plant food (e.g., 10 kg) to make a kilogram of meat. Noticeably reducing livestock production, or reducing the amount of animal products in future diets, would quickly free up extensive areas of land for other uses. Crops on better pasture soils would produce considerable plant food for the next billion people. Natural systems rapidly covering less suitable pasture soils, including many dry areas, would significantly reduce erosion, improve groundwater and surface water bodies, and improve wildlife habitat. Furthermore, the extensive area of crops currently grown for animal feed would drop. Also, crop areas planted for transportation fuel seem more appropriate for food production (Dirks et al., 2012). In moist areas, portions of today's cropland might be converted to fruit production.

Adding these solutions together, even some of them or a small number of all, would creatively provide ample food-producing land for the billion new people.

19.5 IMPROVING NATURAL LAND

Overall the most valuable natural areas are considered to be: (1) large contiguous natural and semi-natural areas; (2) major water bodies; and (3) vegetation strips alongside water bodies (Forman and Sperling, 2011). Large vegetation patches in farmland and in urban land are appropriately included in (1), though key functions differ somewhat. An 'emerald network' of large green areas connected by corridors or 'stepping stones' is a particularly valuable integrative pattern for sustaining nature. This provides multiple ecosystem functions, such as sustaining biodiversity, providing habitat connectivity, protecting water bodies and providing flexibility for the future (Forman, 1995, 2008; Lovell and Taylor, 2013).

19.5.1 In Urban Regions

Large natural or semi-natural land (especially woodland) adjoining or near an urban area provides a huge array of environmental, human and economic benefits (see Figure 19.4) (Forman, 2014), including: (1) reservoir protection and clean water supply; (2) flood reduction; (3) nature-based recreation opportunities; and (4) biodiversity protection and enrichment for the urban area. On vegetated hillslopes/mountain slopes by the built area, natural land provides major additional benefits: (a) erosion, mudslide, sedimentation and flood protection; (b) cool air drainage at night that both cools and cleans the urban air, especially important with climate warming; and (c) no damage to human structures from earthquakes and fire sweeping upslope. Large natural land upwind supplies clean moist cool air to the urban area. Two or more large protected woodlands provide flexibility and stability. Protected natural-ecosystem patches (see 'N' in Figure 19.4) between a large protected area and the urban area serve as key stepping stones for species movement.

A ring of relatively large parks (see Figure 19.4), each generally containing considerable semi-natural areas, immediately around a city or metro area also provides many societal values. Intensive recreation opportunities are close to most residential areas, and neighborhood groups help care for the parks when government maintenance budgets are down. The ring also provides stepping stones for species movement around and into the city.

Greenspaces within a city, some with semi-natural vegetation, help cool summer air, reduce flooding, sustain high biodiversity and provide recreational opportunity. Large-to-small parks and other greenspaces can be spatially arranged to achieve these values over the entire built area (Forman, 2014). In short, economic and social benefits of greenspaces in urban areas are manifold and increasingly recognized (Lovell and Taylor, 2013; Forman, 2014; Wolch et al., 2014; Wu, 2014).

19.5.2 Natural Lands Worldwide

Typically the most effective way to sustain a clean water source for people is to surround it with continuous natural vegetation. Vegetation covering the drainage basin of a reservoir minimizes surrounding soil erosion, and thus sedimentation and loss of reservoir capacity. Minimizing agricultural, industrial and other pollutants, and therefore water treatment costs, provides economic value. With a concentration of microhabitats around water sources, such protected natural land is particularly effective in sustaining biodiversity.

Stormwater and atmospheric pollutants from transportation, industry, agriculture and built areas can be effectively cleaned, especially by filtering through most natural soils and wetlands. In dry climates, considerable water often exists around built areas, but it is largely polluted and needs cleaning for diverse human uses and ecosystem functions.

Transportation's dense road networks subdivide nature's large populations of animals and plants into small populations (Forman et al., 2003; Laurance and Balmford, 2013; Perz, 2014). But small populations commonly have both demographic and genetic problems, which increase the probability of local species extinction. Perforating roads with wildlife crossings (especially when upgrading bridges and culverts), and constructing strategically located wildlife underpasses/overpasses, helps reconnect the land for critical species movement. Many approaches can reduce traffic noise that inhibits sensitive animals in wide areas near busy roads. Near built areas, such solutions can also increase scarce interconnected trail networks for relaxed walking and for hikers.

Looking further ahead, a 'netway-with-pods' system would transform much of today's extensive transportation imprint back to natural ecosystems and other uses for society, and reconnect all surrounding land (Forman and Sperling, 2011). Further benefits of the netway system include increased safety and efficiency, no fossil fuel use, no greenhouse emissions, and increased market gardening and trail networks near communities.

19.6 IMPROVING BUILT COMMUNITIES

19.6.1 Sprawl and Outer Suburbs

Distinct diverse vibrant town and neighborhood centers are the crown jewels here. Mixed-use patterns at both sprawl/suburb and residential area scales provide walkable/bikeable employment opportunities near homes. An efficient transportation system has industrial and commercial centers connected to the regional highway system; primary routes between commercial and middle-income residential areas; secondary routes connecting low-income residential with commercial and industrial areas; and tertiary routes connecting middle-income residential with industrial center and low-income residential areas.

Major population growth might be targeted to degraded natural and farmland spaces (e.g., abandoned fields), or to communities losing population. Or concentrate growth near industrial areas, highway intersections, or railway facilities. Thus jobs and housing are close together. Many informal squatter settlements across urban areas grow in such locations. With inadequate infrastructure investment, serious environmental problems are characteristic. Yet these residential areas also seem to have disconnected impervious surfaces, plus considerable bare soil, native and non-native woody plants, spontaneous vegetation, and somewhat rich biodiversity (Muller et al., 2010; Biggs et al., 2010; Forman, 2014).

Alternatively, concentrate population growth in low-density residential areas with attached or detached single-unit houses on large, medium or even small plots. Densify near existing and proposed wastewater sewer lines, near public transport routes and near convenient shopping areas. Use novel approaches. Change property lines so houses are built between houses, reduce building setback regulations, greatly increase floor area ratios, convert large houses into apartments/condominiums, grow buildings on lawns and yards, create narrow wildlife corridors through blocks, and so forth. But for each housing unit, retain a tiny green private space for children's use, vegetable growing, aesthetics, and physical and mental health (Kellert et al., 2008; Reeves, 2014). Do single-family housing densities of 5, or 25, or 40 units per hectare (Davies et al., 2009; Cilliers et al., 2012) provide an appropriate minimum size for private spaces?

19.6.2 City and Inner Suburb

Major population growth in densely populated areas seems counterintuitive if overall quality of life and links with nature are important. Existing high-rise, low-rise and courtyard/patio residential areas are commonly short on green spaces, local employment, local shops, and public transport, while suffering from excess urban heat, air pollution, traffic and noise. Urban infill commonly exacerbates the problem (Forman, 2014).

Is the urban status quo improvable near term to permit suitable living for major population growth? For instance, redesign wide, dangerous, noisy traffic-jammed roads to create quiet, vegetation-embroidered neighborhood spaces, easily connected by walking/biking, plus taxi-like vehicles and service vehicles. Create cultural, shopping, civic meeting places, as valued centers of distinctive communities for residents in the urban sea of buildings and roads. Shrink our home ranges, with jobs, residences, parks, schools and so forth arranged closer together, thus reducing transportation time and cost. Increase public transportation of varied modes, with walking/biking-only routes alternating with personal vehicle and public transportation routes. Test more visionary approaches.

Across the entire urban area, create a tree-anchored 'green net', tying together an abundance of parks, greenspaces, neighborhood centers, playgrounds, ballfields, urban agriculture, flower gardens and planters (Rosenzweig, 2003; Forman, 2014). Locate trees to clean the air, and also trees to cool the air. Emphasize plants with low water usage and high bird/pollinator usage. Enhance urban neighborhoods and a sense of place for residents who readily care for the green net (Ndubisi, 2014).

To decrease urban heat, impervious surfaces are reduced, whitened or covered with plants. To decrease flooding and polluted local water bodies, impervious surface areas are fragmented into small sections and disconnected from water bodies. Stormwater runoff is readily funneled to detention and retention basins/ponds/wetlands, as well as diverse greenspaces. Stormwater mitigation for streams leaving an agricultural area, plus entering and leaving a built area, is strategically valuable (see Figure 19.4). So, reduce, fragment and disconnect impervious surfaces, while increasing and connecting greenspaces and waterways.

Yet, before densifying city and inner suburb areas, much more needs improvement – water supply, human wastewater, food systems, solid waste, pests and disease vectors. Furthermore, big disturbances happen, often becoming 'disasters' in built areas. Solutions providing both resistance and resilience, and largely spatial, are reasonably well known (Forman, 2008; Ahern, 2013; Wu and Wu, 2013), but alas, rarely implemented in advance.

To mold the land so nature and people both thrive long term (Forman, 2008) future sustainability will require better design and planning of our land – backyard, neighborhood, city and urban region. Before adding a billion people, what actions would provide multiple values for farmland, natural land and built communities, and noticeably improve each region of the globe (Table 19.1)?

19.7 CONCLUSION

Based on environmental constraints (especially water stress; and including key biodiversity areas) plus existing population density, the best places for major human population growth at the global scale seem to be large areas of South America; across central and eastern Northern America; scattered areas of Oceania; Asia north of the Himalayas and in a central east–west strip; and south-central Africa. This pattern sharply contrasts with population growth projected to overwhelmingly occur in Asia and Africa. Global/regional scale migration from high growth rate areas toward more suitable freshwater and other resource areas is likely to continue, and increase.

At the urban region scale, based on expected degradation or loss of food-producing land and natural land, today's outer suburbs, exurban sprawl areas, satellite cities, and towns/villages in farmland seem best suited for adding the next billion people. This conclusion also differs from projected population growth mainly in cities.

Global-scale land planning and human migration regulation currently seem impractical for this enormous population growth challenge. Thus urban region-scale planning and implementable solutions seem urgent.

Table 19.1 Encapsulated actions to improve lands during major population growth

Farmland	Natural Land	Built Communities
Protect best soils and enrich others	*Protect/expand* the integrity of large green areas	*Protect/enhance* water supply with vegetation
Establish market gardening areas by all cities	*Remove* remote roads and buildings degrading nature	*Disconnect* impervious surface areas
Accelerate urban agriculture	*Connect* large green areas with corridors and/or stepping stones	*Shrink* human home ranges
Close/relocate industries polluting key farmland	*Perforate* roads to facilitate wildlife crossing/ movement	*Transform* busy noisy roads to quiet neighborhood spaces
Reduce livestock and meat to gain land for edible crops	*Expand* vegetation protecting water bodies, and along headwaters and intermittent channels	*Arrange* urban greenspaces to cool air, reduce flooding, support biodiversity and enhance recreation
Reduce cropland used for fuel and animal feed	*Increase* bits of nature across farmland and built areas	*Convert* sprawl areas to denser mixed-use areas with vibrant neighborhoods
Use more food species and varieties		*Grow* a tree-anchored green net
Replace annual grains with perennial grains		

Unplanned urbanization, notably its sequential spatial arrangement, has major impacts on food-producing areas, natural land and built areas. A wide range of actions to improve, or minimize negative effects on, areas for food, nature and community are outlined. No single overarching solution emerges. Yet many individual solutions address a number of problems. Therefore, a package of specific solutions, most strongly spatial and each addressing two or more issues, seems promising to mold a better land ahead. With the human ecological footprint apparently exceeding the Earth's biocapacity, unless the land worldwide is effectively improved, another billion people is a bad omen.

NOTE

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