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green belts, however, did not materialize as planned; land owners and social reformers often opposed them for limiting the growth of cramped cities, resulting in abandonment or compromise.

Europe's Ecological Networks

In the shadow of this vast proliferation of nature reserves and green belts, nature conservationists started to combine green nodes and links into emergent notions of ecological networks. Their successors today locate the genesis of ecological networks in the Soviet republics of Estonia and Lithuania in the 1970s. In Western Europe, biologists and planners conceptualized the Netherlands' National Ecological Network in the 1980s, which in turn inspired Pan-European nature planning in the 1990s.[52]

Baltic ecological network builders did not credit new biological subdisciplines, such as systems ecology and ecological engineering, as their sources of inspiration, unlike their Western colleagues. Instead they drew on human-centered nature considerations in geography and topological planning. They eagerly cited the Russian geographer Boris Rodoman, who translated planning concepts of "polarized landscapes" and "functional zoning" into a management tool for biosphere preservation. In Rodoman's view, central planners should divide a given territory into separate zones with different functions. Intensive land use in urban, industrial, and cultivated zones should be flanked by integrated nature zones to purify the air, clean groundwater, prevent erosion, and protect habitats, in short, to compensate for the environmental damage done by humans. Such landscape polarization in economic and ecological zones entered central planning in a number of Soviet and Comecon states in the late 1970s and 1980s. Estonian university researchers and planners spoke of a "network of compensative areas" from the mid-1970s. Their Lithuanian colleagues agitated for a "nature frame" from the early 1980s, and their Czechoslovak peers started to work on a "system of landscape territorial stability."[53]

Ülo Mander, who worked at the Estonian Agricultural Academy from the late 1970s and chaired the Estonian Association of Landscape Ecology two decades later, noted in retrospect that the Estonian national ecological network "might be called an

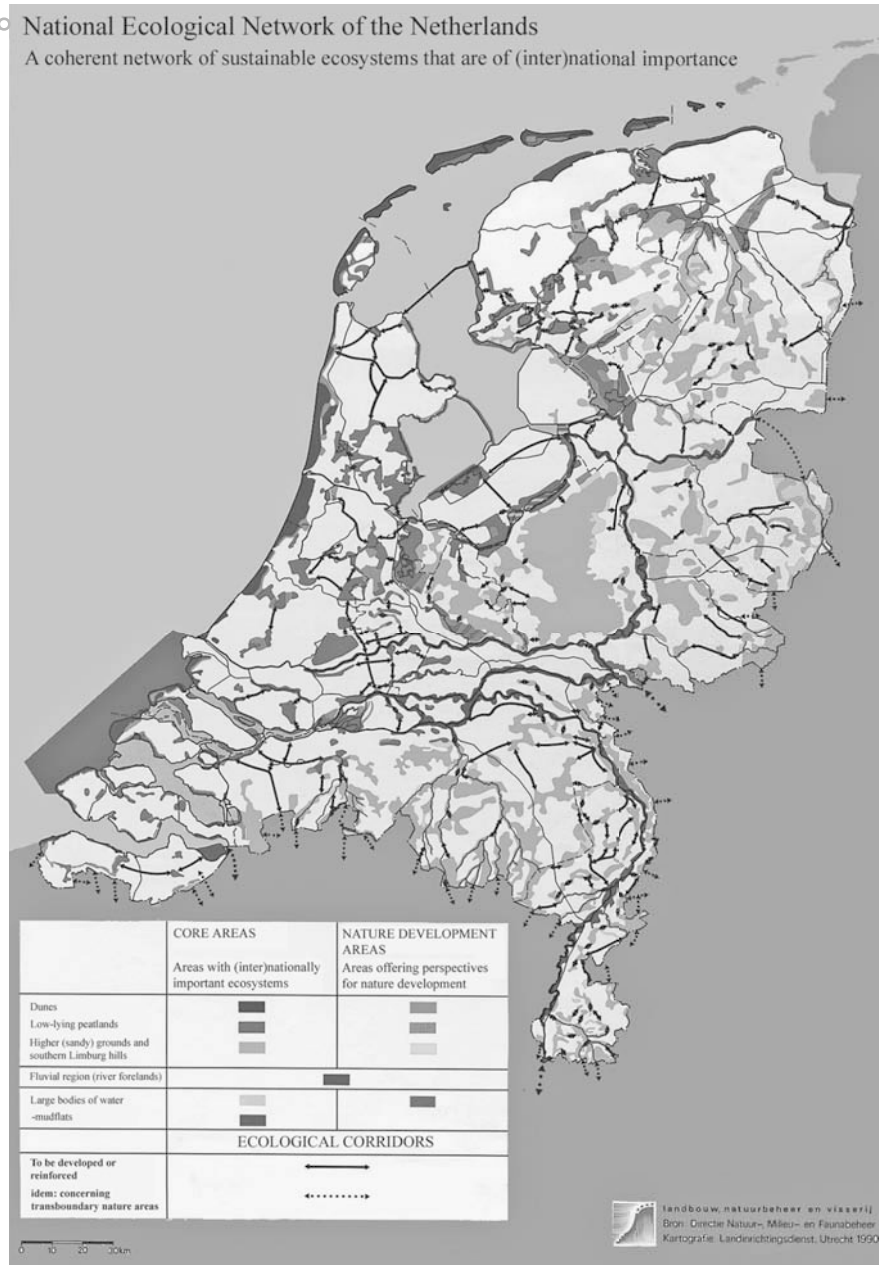


Fig. 6.6 National Ecological Networks: *From the 1970s, ecological system-builders have developed the concept of ecological networks or "green infrastructure." In Eastern Europe, the concept was pioneered by Estonian geographers. In Western Europe, the national ecological network of the Netherlands—one of the most ecologically-fragmented countries in the world—became paradigmatic. The network became a national policy objective in 1990. It connects isolated "core areas" and "nature development areas" (low-lying peat and clay areas, river forelands, sandy soils, dunes, and marine mudland ecosystems) by means of "ecological corridors."*

ecological infrastructure to compensate [for] intensive economic activities."[54] Mander and his colleagues remember how the stage had been set in Estonia. After the Soviet annexation, central planners had concentrated agriculture in collective or state farms

in fertile Upper Estonia. By the early 1970s that strategy had produced severe soil and water pollution near large farms and heavily-fertilized fields. Functional zoning ideas thus fell on fertile ground. University of Tartu researchers teamed up with state planners to conceptualize and design an interconnected network of compensating areas to absorb human pollution and renew natural resources. Their Land Construction Project used satellite images to identify bottlenecks in the pristine ecological network, and published several national network designs between 1977 and 1983. These schemes used existing river valleys and forest zones as links among large nature reserves and less-intensively-used areas. A few new-built and relatively short green connections could close the gaps.[55] During the 1980s planners elaborated the network on a district scale with the aid of aerial photography and field data. In 2000 the Estonian ecological network covered over 50 percent of the country's land territory. By then the human-centered justification for the ecological network—purifying nature to compensate for and sustain the human habitat—had given way to the Western conception of preserving nature "for its own sake." Estonian ecologists now emphasized that the network had a positive effect on species such as the protected Clouded Apollo butterfly, *Parnassius Mnemosyne*. Populations of this butterfly had decreased vastly throughout Europe, but in Estonia the species' presence grew and expanded along riparian meadow corridors with alder strips on river banks. These ecological corridors, later studies suggested, hosted the larvae food plants and adult mating places and provided shelter for a butterfly population that seeks to avoid high speed winds.[56]

The human-centered Eastern European ecological network debate hardly resonated in Western Europe. Instead, Western advocates of green infrastructure drew on the nature-centered scientific disciplines of systems ecology and ecological engineering developed in the United States.

During the 1960s the brothers Eugene and Howard Odum had successfully promoted ecological systems as the appropriate study unit of biological organization. In a self-regulating ecosystem equilibrium, key inputs such as energy and carbon entered the system by photosynthesis in green plants and subsequently cycled through the system's natural food chains. The Odums and others called for human intervention and "ecological engineering" to

create better initial conditions; after that ecosystems would be self-sustaining. Robert MacArthur and Edward O. Wilson's equilibrium theory of island biogeography further fueled the debate about how to engineer better nature reserves: larger and more diverse habitats allowed more species, because migration helped species evade local extinction by chance events. The International Union for the Conservation of Nature endorsed the theory in its World Conservation Strategy for "genetic diversity" of 1980.[57]

In the Netherlands, where intensive agricultural system-building had almost depleted nature, Fred Baerselman and Frans Vera studied these ideas as classmates in biology at Amsterdam Free University in the early 1970s. They joined biologist and activist critiques of the "unnaturalness of Dutch forest and nature zones," which dismissed traditional human-centered nature conservation as "large scale gardening." Instead they agitated for targeted interventions to create "real nature." As prominent policy entrepreneurs promoting ecological networks for the Ministry of Agriculture, Nature, and Food, they would later call the Netherlands an "ecological disaster area": land use statistics counted only 6 percent of the territory as "natural" (excluding some 8 percent of production forests).

Since omnipresent farm fields prevented the expansion of isolated nature reserves, they proposed "some unusual and unorthodox ideas to restore and develop nature... As always: necessity is the mother of invention."[58] To boost the possibilities for species to migrate, a 1981 nature policy proposal to Parliament aimed "to construct corridors or 'stepping stones' between nature reserves, so as to realize a kind of ecological infrastructure."[59] During the 1980s Baerselman, Vera, and a handful of others further developed the concept's key elements. "Ecological core areas" were nature reserves large enough for complete and self-regulating biotic communities, and "can also be used as reservoirs from which smaller wildlife areas can be supplied with plant and animal species."[60] Areas too small to be biodiversity generators could function as "stepping stones" for species migration. Finally, "ecological corridors" such as watercourses, wayside verges, or simply strips of greenery across agricultural lands should facilitate the migration of species between these ecological nodes.

The Dutch Parliament endorsed the proposal in its 1990 Nature Policy Plan, which projected a National Ecological Network for 2018. To the grave disappointment of Baerselman and Vera, their

agency's director gave in to agriculture interests and abandoned a strict separation of nature from other land uses: "The concept of the ecological network has been endorsed ... but the ecological departure point has been partly put overboard, and the ecological network now comprises other activities such as production forests, military zones, and agriculture. The rhetorical power of the policy document ... legitimates the damaging of nature," complained Vera.[61] Nevertheless the construction of a national ecological network began. By 2011, when Government and Parliament quarreled about withdrawing corridor funds after the European sovereign debt crisis, provincial authorities had acquired some 50 percent of the targeted land and had built 30 percent of the network. In some 270 locations the national ecological network crossed motorways and railroads; here ecological system-builders built so-called green-grey junctions such as ecoducts (viaducts for plants and animals) and badger or toad tunnels.[62]

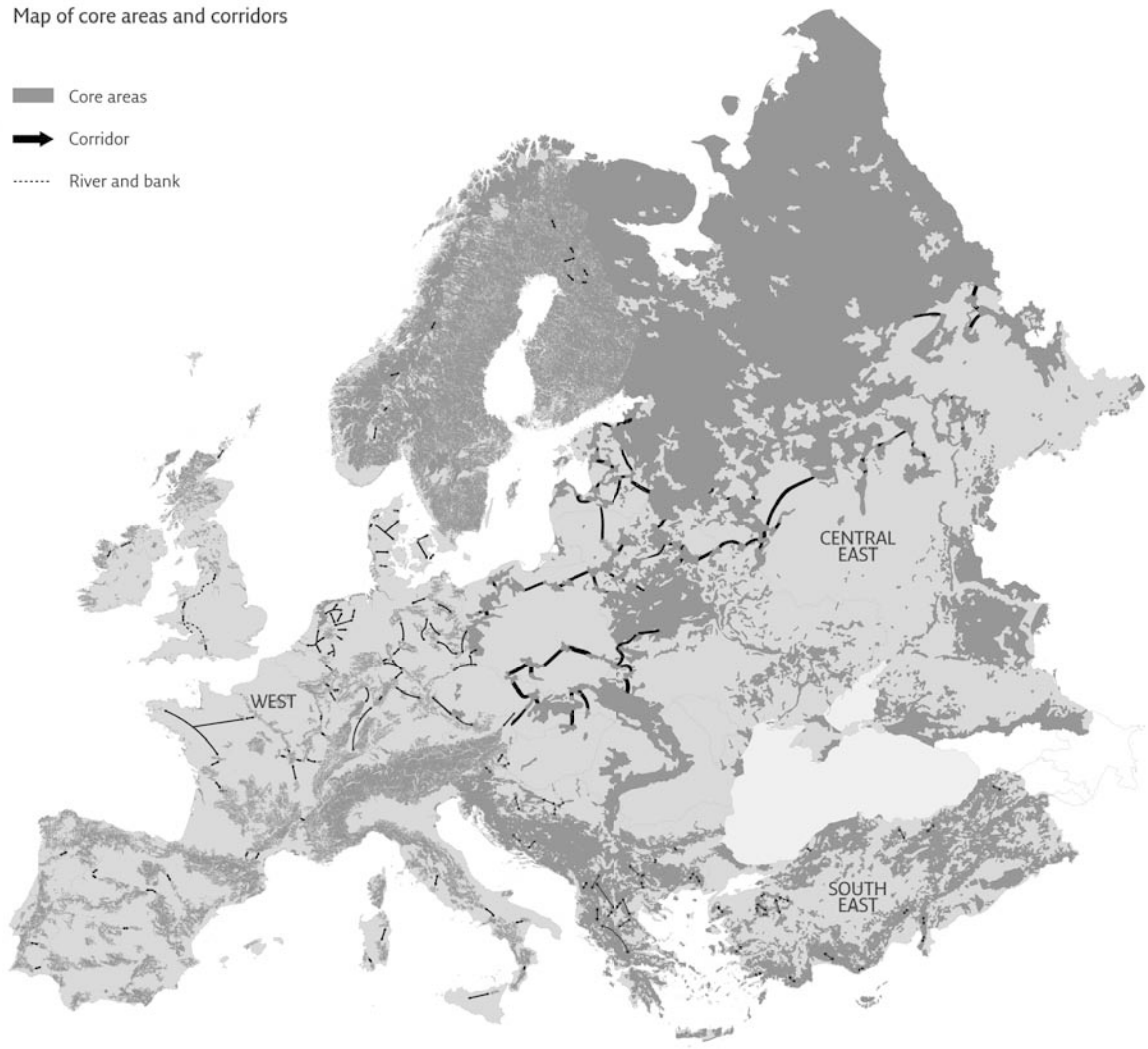
Baerselman and Vera's scheme had included cross-border corridors reaching Belgian and German nature areas and anticipated further upscaling: "The 'national ecological network' can be one of the starting points for a 'European Ecological Network', that should preferably be developed from several starting points simultaneously."[63] When the Dutch government held the rotating presidency of the European Communities in 1991 and hosted the ongoing negotiations on the Habitat Directive (an extension of the 1979 Birds Directive to other species), Dutch ecological network builders seized this opportunity.[64] Promoting their national solution as a European one, they used the CORINE land use database to draft an interconnected European Ecological Network and presented it to the Communities' Council of Environment Ministers. To the regret of the scheme's main author, Graham Bennett, the EU's Habitat Directive and *Natura 2000* vision (the combined nature reserve system of the bird and habitat directives) obliged governments to designate nature reserves, and put corridors second as a voluntary option.

Bennett and his collaborators then convinced the Dutch and Hungarian governments to host a major conference in Maastricht under the banner of the European Commission, the Council of Europe, and the International Union for the Conservation of Nature. The conference declaration announced a new European Center for Nature Conservation, which together with the Council of Europe

Fig. 6.7 From Iron Curtain to European Green Belt: *One of the most ambitious attempts to reconnect Europe's nature is the European Green Belt project. Some 150 governmental and non-governmental organizations from 16 EU countries and 8 non-EU countries collaborate to turn the former Iron Curtain, where wildlife thrived in the absence of human settlement, into a green corridor. The belt measures 12,500 km, from the Russian–Norwegian border at the Barents Sea to the Mediterranean and the Black Sea. The photograph shows a part of the European Green Belt at the Austrian–Czech border near Linz, Austria.*

would propose an interconnected European ecological network at the upcoming "Environment for Europe" ministerial conference in Sofia. There forty-six governments promised to implement the so-called Pan-European Ecological Network, defined, following the Dutch model, as "a physical network of core areas ... linked by corridors and supported by buffer zones, thus facilitating the dispersal and migration of species."[65] After all, supporters proclaimed, "nature does not have any borders."[66]

Europe's ecological system-builders soon found out that the realization of such a pan-European network within ten years was overly optimistic, but nevertheless started a number of actions. Much effort went into developing indicative maps at a 1:3,000,000 scale for Central and Eastern Europe, South-eastern Europe, and Western Europe. To designate ecological core areas, they combined data on existing protection sites and threatened species with land cover data. The latter exercise required the complicated alignment of land use databases such as CORINE 2000 for the European Union, Swiss, and Norwegian land use data, and less detailed



Pan-European and global data sets. To determine the location of ecological corridors they drew on geographical data on river valleys and bird migration routes, as well as the opinions of national and (micro) regional experts, whose detailed knowledge on connection possibilities proved indispensable especially for densely-cultivated areas. Subsequent ministerial conferences endorsed the proposed maps, but did not enforce their implementation. Thus Europe's ecological network builders attempted to inspire and coordinate local, (micro) regional, national, cross-national governmental and non-governmental initiatives within the maps' framework. The European Green Belt traversing twenty-two countries along the

former Iron Curtain is an example of international cooperation of non-governmental environmental associations coordinated by the International Union for the Conservation of Nature. Most programs, however, had a national focus such as the Baltic states', Dutch, German, Moldavian, Polish, Romanian, and Ukrainian government programs, or a regional approach such as the programs of Spain's Extremadura, Andalusia, and Catalonia Autonomous regions, the University of Aquila program in Italy's central Apennines, or Danish province-level corridor planning.[67] In the Baltic states, where ecological networks had been pioneered, the Pan-European initiative triggered a convergence with the Western network concept: "The existing network of protected areas as well as the ecological network should be re-evaluated at [the] European level," noted Estonian ecologists in 1999. They then proceeded to reshape their network in terms of core areas, corridors, buffer zones, and cross-border connectivity.[68]

Parnassius Mnemosyne *or* Lepus Europeus

Fig. 6.8 Mapping the Pan-European Ecological Network: *The most ambitious and challenging green infrastructure project proved to be the construction of a Pan-European Ecological Network (acronym: PEEN). The effort to connect nature zones by ecological corridors on a pan-European scale started in the late 1990s with the development of indicative maps, based on existing nature reserves, land cover databases, and geographical data on river valleys and bird migration routes. The thick lines on this overview map are green corridors.*

Estonian ecologists credited their networks for the revival of an endangered butterfly, the *Parnassius Mnemosyne* or Clouded Apollo. Their Dutch colleagues celebrated the successful spread of beavers, otters, badgers, and black storks alongside a wide array of other rare birds, reptiles, insects, and plants. Czech botanists found that one of their earliest local corridors—the merely 15 meter wide *Vracrov* link across agricultural land—and an early regional corridor showed successful sustenance of indigenous woody plants and willows, respectively.[69]

However, in a 2011 report the European Environment Agency suggested that the rapidly-declining Central European population of the European hare, the *Lepus europeus*, may be more representative of the current state of Europe's ecological system-building. Due to habitat fragmentation by agriculture and transport infrastructure, in several countries "its extinction seems impossible to prevent, as the 'point of no return' has probably been crossed several years ago."[70] On a higher level of aggregation the Agency observed that ongoing habitat fragmentation simply outran ecological network building: "In spite of the planning concept of preserving large

unfragmented areas, fragmentation has continued to increase during the last 20 years, and many more new transportation infrastructure projects are planned, especially in Eastern Europe." On balance, "fragmentation of landscapes is rising and the remaining ecological network provides less and less connectivity."[71]

Unable to stop fragmentation, Europe's ecological system-builders had other problems as well. The binding legislation of the EU *Natura 2000* program drew available funds to nature reserves rather than ecological corridors. In addition, ecological network builders increasingly met opposition. French farmers protested fiercely against returning cultivated land to nature. The "Natura 2000 out of Bulgaria" movement protested all nature conservation efforts that hampered economic growth and employment. Norwegian locals lamented the increased circulation of lynx, wolverine, bear, and wolf that damaged livestock and scared people away from wandering through the woods; they loathed ecology as an urban elite project threatening rural lifestyles. Even in the pioneering Netherlands, farmers' organizations and their political allies clashed with nature managers, paying game hunters to position themselves at ecoducts to shoot red deer or lobbying for fences on top of expensive new ecoducts to prevent Belgian wild boar from eating Dutch crops. In addition, ecological networks may also carry so-called "invasive species"; some of these animals, plants, and microorganisms threaten indigenous species and reduce rather than sustain biodiversity (though most invasive species travel via transport infrastructure rather than ecological networks). Finally, ecological system-builders regretted their incapability to coordinate their own efforts: "ecological networks are being developed at the country or regional level, but at the European and global level there are mainly visions."[72]

Europe today hosts a number of ambitious cross-border ecological connection programs. The Green Lungs of Poland program, for instance, includes border crossings to Estonian, Belarusian, Latvian, Lithuanian, Russian, and Ukrainian nature zones. Nevertheless, for the reasons listed above, on aggregate Europe's transnational nature conservation constellation continues to gravitate around local and regional protected areas, with comparatively weak national and international linkages. Nature conservation's Europe, in other words, remains chiefly the Europe of local and regional initiative.

As for biodiversity, a number of species managed to cope with ongoing habitat fragmentation. They simply defied existing classifications, and settled inside the human habitat. The European Environment Agency recognizes that about half of Europe's biotopes and species now live in agricultural terrain. This makes upgrading agricultural fields with hedges, ditches, and other "semi-natural elements" an important conservation strategy. From this perspective, the human habitat–nature dichotomy and its exclusive focus on creating new wilderness might harm rather than boost European biodiversity. The Agency further notes that surprisingly many species even inhabit towns and cities; the so-called "urban forest" is made up of "urban wetlands, abandoned industrial sites, roadside verges, vacant lots and derelict lands, ruins, allotment gardens and cemeteries ... together with arboreta, residential gardens and villas, botanic gardens and individual balconies."[73] Europe's species, it seems, developed through complex interactions with ecological networks, as well as with the networked human habitat described throughout this book, and continue to do so today.

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47 The plan is cited in Reeder, "Social Construction of Green Space," 65. See also: Amati and Yokohari, "Establishment of the London Green Belt"; Clark, *European City and Green Space*; Amati, *Urban Green Belts*.
48 Quotations from: Council of Europe, *European Diploma for Certain Protected Landscapes*; Council of Europe, *Convention on the Conservation of European Wildlife*. See also: IUCN, *Tenth Anniversary 1948–1958*; Jepson and Whittaker, "Histories of Protected Areas"; Rink, "Environmental Policy and the Environmental Movement"; Meyer, "L'européanisation de la politique environnementale."
49 United Nations, *Declaration of the United Nations Conference*.
50 Figures from IUCN, *2003 United Nations List of Protected Areas*, 25–26, which for the first time included areas smaller than 10 km^2 and unclassified areas.
51 House of Commons Debates, Volume 556 (July 9, 1956), p. 52, available at http://hansard.millbanksystems.com (accessed March 14, 2012). See also: Clark, *European City and Green Space*; Amati, *Urban Green Belts*.
52 Jongman, "Nature Conservation Planning in Europe"; Jongman et al., "European Ecological Networks and Greenways."
53 Sepp and Kaasik, *Development of National Ecological Networks*; Miklós, "Most Successful Landscape Ecological Concepts."
54 Mander and Palang, "Changes of Landscape Structure in Estonia," 53. See also: Sepp et al., "Prospects for Nature and Landscape Protection in Estonia"; Meier et al., "Riparian Buffer Zones"; Külvik, *Ecological Networks in Estonia*.
55 Jagomägi, "Ökoloogiliselt tasakaalustatud maa"; Aaviksoo, "Changes of Plant Cover."
56 Meier et al., "Riparian Buffer Zones."
57 Odum, "Man and Ecosystem"; Odum, "Strategy of Ecosystem Development"; Mitsch and Jørgensen, "Ecological Engineering"; IUCN, *World Conservation Strategy*.
58 Baerselman and Vera, *Nature Development*, 57. Statistics Netherlands, *Vijfenegentig jaren statistiek*, 12. Verduijn et al., "Discursive Framing and Network Strategies"; Van der Windt et al., "Valuing Nature in the Context of Planning."
59 Tweede Kamer der Staten Generaal, *Structuurschema Natuur en Landschapsbehoud*, 34.
60 Baerselman and Vera, *Nature Development*, 42.
61 As quoted in Schmit, "Landbouw dicteert meer dan ooit." See also: Verduijn et al., "Discursive Framing and Network Strategies."
62 Bennett and Mulongoy, *Review of Experience with Ecological Networks*; Jongman and Bogers, "Current Status of the Practical Implementation of Ecological Networks."
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65 As quoted in Benett and Wolters, "European Ecological Network," 16.

66 Bouwma, "Progress in the Development," 17.
67 Jongman et al., "Pan-European Ecological Network"; Remm et al. "Design of the Pan-European Ecological Network." Project overviews: Jongman, "Nature Conservation Planning in Europe"; Jongman et al., "European Ecological Networks"; Bennett, "Interaction between Policy Concerning Spatial Planning and Ecological Networks in Europe."
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7 Troubled Waters

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7 Gatterer, *Abriss der Geographie*; Molle, "River-Basin Planning and Management," 485. Buache defined a river basin as "the set of all slopes on which fall the waters that converge to a same river or creek."
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13 Ibid.