Vienna. A building of social flats owned by the city of Vienna, Hundertwasser has transformed it into a green flowing piece of urban nature. The building reflects Hundertwasser's basic belief that there exists an obligation to replace every bit of nature taken in the process of construction and city building. The result here is an extensive set of roof gardens and terraces, and windows overflowing with trees and vegetation. In Hundertwasser's words: "Everything horizontal under the sun, under the open sky belongs to nature. Roads and roofs should be planted with trees. It must be possible to breathe forest air in the city again . . ." (Rand, 1993, p.146).

Other key concepts in the Hundertwasser philosophy include the notion of *tree tenants*—the idea that every window ought to have a tree growing out of it. In the Hundertwasser Haus design, every flush of the building's toilets waters these trees. Another of his ideas is the *window right:* the right that each tenant has to change the facade of a window (as far as they can reach out and around the window). (The latter is actually included in apartment leases, although such modifications apparently also require city approval). Other features of the Hundertwasser Haus include a winter garden, which is common space in the building, an adventure room with an undulating floor (popular with the children in the building), and the extensive use of recycled materials (such as bricks from demolished buildings and recycled tiles). The exterior of this and other Hundertwasser buildings are colorful and daring, including the extensive use of colored tiles, upside-down cones and columns, and windows of many different shapes and sizes. The result of Hundertwasser's work is a unique and stimulating mix of the natural and the artistic. The house remains an early example of how buildings and urban structures can contribute to the greenness of cities rather than detract from them.

The tangible forms that greenness and strategies for naturalizing cities take are varied and diverse. Many of the cities examined have, for example, made impressive efforts at urban tree planting. There are some 400,000 trees in Berlin alone. Indeed, flying into Berlin one gets a feeling (at least in spring and summer) of descending into a green oasis, not a heavily urbanized city. Freiburg has substantially increased its number of trees in the last ten years, now numbering about 25,000. Erlangen has planted some 30,000 trees since 1972 (Deutsche Umwelthilfe, 1991). Cities are also implementing a variety of landscaping and greening standards. Many of the cities have specific tree planting standards. In Graz, for example, new parking areas must include trees at the rate of one tree per every three spaces.

Many positive examples can be cited of new housing projects that incorporate trees and vegetation as major design elements. One example is the GWL-terrein project in Amsterdam. Here, the trees are planted in main courtyards, surrounded by a shallow layer of brick, and given ample room for aeration and water. The design and planning of streets and roads can also offer many opportunities to incorporate trees and greenness. The Dutch have been especially creative at planting trees in the streets. In this way, trees have both a greening and a traffic-calming function.

The *woonerf* concept, or shared-street concept (discussed in Chapter 5), utilizes trees and vegetated areas as a technique not only for slowing traffic, but also for greening the street. Many examples of streets in cities such as Den Haag (e.g., Statenkwartier) can be cited where trees have been planted a few feet into the street and between on-street parking. In Utrecht, the Het Groene Dak housing project has taken a creative approach by planting trees and vegetation in a certain number of on-street parking spaces. By determining that fewer cars than average were owned by residents of the project, and by convincing the municipality to reduce the parking required, these unneeded spaces became green areas instead. Projects such as Het Groene Dak illustrate the potential for accommodating substantial urban density (sixty-six units per hectare in this case) while minimizing paved surfaces and creating delightful green and wild spaces in an inner communal garden.

Efforts have also been made in many of these cities to avoid large areas of paving or hard surface without trees and vegetation. Unlike many typical American parking lots, for example, the parking lots in these cities typically include tremendous trees and shading. Notable examples of city parking lots with a high tree density can be seen in Odense and Saarbrücken. Very often permeable brick or paving material is also emphasized. A positive example of green parking lot design is found in Leiden along the street Hooglandsekerkgracht, a very urban street with a center island devoted to about fifty parking spaces. With wide crowns and strategic spacing, virtually all of the parking is shaded by eighteen relatively large trees during the summer, which provides another important element of green in this otherwise dense urban environment.

Greenroofs: Creating Meadows in the Sky

Greenroofs, or *eco-roofs* as they are sometimes called, have become increasingly common in Europe, especially in Germany and the Netherlands, and provide many benefits over conventional roofs. Among their key advantages are the protection they provide from UV rays and the

ability to extend the life of a roof, the ability to cool the urban environment (addressing the urban heat island effect), carbon dioxide sequestration, the control of stormwater runoff, and the provision of significant habitat, especially for plants, invertebrates, and birds. Butterflies have been found in U.S. studies to visit rooftop gardens as high as twenty stories. German studies have demonstrated a considerable biodiversity on greenroofs there (Mann, 1996). While the short-term cost of a greenroof may be higher, these costs can be more than outweighed by the added life of the roof.

Greenroofs can also provide extensive added insulation (as high as a 10 percent increase, according to Johnston and Newton, 1997). There are also public relations benefits to be had: "Green roofs clearly attract interest and usually result in a positive image for those organizations that instigate them" (Johnston and Newton, 1997, p. 50). It has been estimated that a rooftop garden in Britain may add between 10 percent and 30 percent to the market value of a building (Letts, 1998). A more complete set of advantages (and disadvantages) is presented in Table 7.1 (from Johnston and Newton, 1997).

Traditionally, two styles or types of greenroofs are distinguished—*intensive* or *traditional* roof gardens, and *extensive* or *ecological* rooftops. The former—typically referred to as *roof gardens*—include structures that can accommodate deep soils, trees, and shrubs, and deeper-rooted vegetation. Because of the depth of the soil cover required for intensive roof gardens, additional structural reinforcement is typically needed, as well as more active and intensive management. Extensive rooftop systems—or *ecological roofs*—typically involve coverage of the entire rooftop with a relatively thin covering of soil and vegetation. These kinds of rooftops are generally designed to involve little maintenance and few inputs and can even be installed on rooftops with a considerable pitch to them (roofs of up to 30 percent slope, according to Thompson, 1998).

The aesthetic benefits should not be underestimated. Several recent German examples visited by the author illustrate the visual difference such roofs can make. In the Cosmos building in Saarbrücken, a simple linear greenroof can be impressively viewed by offices on several higher floors. There is a remarkable feeling of looking out over a farm field or pasture, in this example. Green roofs have the potential to make a tremendous difference in the visual landscape and qualities of cities. As one British observer notes "It's depressing to look round a city and see so many grey spaces. People are starved of greenery. This puts a little back" (Ambrey, 1994, p. 3). The Saarbrücken energy company building ("the building of the future") also has a green rooftop, largely planted in flowering plants.

Table 7.1. Roof Gardens and Green Roofs: A Comparison

ROOF GARDEN INTENSIVE	GREENROOF EXTENSIVE
traditional	*ecological*
Deep soil, irrigation system, more favorable conditions for plants.	Thin soil, little or no irrigation, stressful conditions for plants.
ADVANTAGES • allows greater diversity of plants/habitats • good insulation properties • can simulate a wildlife garden "on the ground" • can be very attractive visually • more diverse utilization of roof (e.g., for growing food) as open space	ADVANTAGES • lightweight roof generally does not require strengthening • suitable for large areas • suitable for roofs from 0°–30° slope • low maintenance • often no need for irrigation/drainage system • relatively little technical expertise needed • often suitable for refurbishment projects • can leave vegetation to develop • relatively inexpensive • looks more natural • easier for planning authority to demand greenroof as a condition of planning permission
DISADVANTAGES • greater weight loading on roof spontaneously • need for irrigation and drainage systems (greater need for energy, water, materials, etc.) • higher cost • more complex systems and expertise required	DISADVANTAGES • more limited choice of plants • usually no access for recreation, etc. • unattractive to some, especially in winter

Source: Johnston and Newton, 1997.

Many of the company's offices actually front on this delightful and colorful green garden. In these cases, the difference between the views workers of this kind of lush roof experience and a conventional (at least in the United States) rooftop is remarkable. The benefits, although difficult to document, are likely to be substantial in terms of happier, healthier, and ultimately more productive employees. There is clear evidence of lower absenteeism and increased productivity in ecological buildings that include

green features (such as the ING bank headquarters in Amsterdam, discussed in Chapter 10), and it is highly probable that similar benefits from greenroofs occur as well.

The use of extensive greenroofs has become increasingly common in the Netherlands, and a number of creative applications there can be cited. Examples of relatively large grass roofs include the terminal building at Schiphol Airport in Amsterdam, the new main library at the Technical University in Delft, and the GWL-terrein housing project in Amsterdam. The renovation of a housing complex for the elderly in the Dutch city of Zevenaar is being fitted with a green roof (the Pelgromhof; a design by green Dutch architect Frans van der Werf). There have been some very creative recent incorporations of grass roofs, including one integrated as a layer into the recent eco-Kantoor (ecological office building) in Bunnik. And in Leiden, even the main train station incorporates a greenroof.

The greenroof used in the GWL-terrein project in Amsterdam is an exemplary design. The plantings have been carefully selected so that, for example, plants that die in summer serve as food for winter plants. When

Greenroofs or eco-roofs are now common in Europe, especially in Germany, Austria, and the Netherlands. Shown here is a multilevel greenroof at the GWL-terrein housing complex in Amsterdam.

visited during the month of June, the roof was spectacularly green and healthy. The roof is an interesting design in terms of water management. The building itself has a tapered form, from seven stories at one end to three at the other. The rooftops are slanted so that excess water draining from upper levels is guided to lower levels of the greenroof, and at the end any remaining water flows to the open ground below. This overflow from level to level occurs though two pipes extending at the end of each roof level. The outer walkways are also rainwater collection points leading to the next lower greenroof level. The GWL rooftops are not really accessible or directly usable by most residents of the building, but all residents are entitled to visit the rooftop area, and there are small areas where residents might bring chairs and sit. The greenroof itself is off limits for walking. The roof has the most direct visual impact for several apartments on the top floors, which have private gardens facing the greenroof. The grass roof is actually quite shallow with substrate extending perhaps 10 centimeters deep. One layering material used in the roof is a kind of lava rock, which absorbs and retains water and helps the plants survive during dry periods. A firm specializing in greenroofs—Ekogras—designed and built the roof.

Several of the early pilot projects in sustainable building in the Netherlands have incorporated grass roofs, notably a section of Ecolonia (in Alphen a/d Rijn), and the Romolenpolder in Haarlem. Haarlem's Romolenpolder neighborhood is one of the most intriguing applications of greenroofs. A part of this neighborhood, consisting of about thirty-five two-story attached homes with flowing grass roofs, shows convincingly the difference eco-roofs can make in greening even low-rise, more suburban-style development. The green rooftops are a visually distinctive feature in the neighborhood and in combination with grass and other forms of vegetation interspersed throughout the neighborhood, give one the impression of being enveloped by green. The residents there are quite fond of the rooftops—they talk about how their homes are cooler in the summer and warmer in the winter, and they appear to be very proud of the distinctive look of the place. The larger Romolenpolder neighborhood, completed in the mid-1990s, was designed and conceived with the environment at the center (see Ministry of Housing, Spatial Planning and the Environment, 1996). Other elements of the neighborhood include a children's farm and education center, an integrated waste collection system, and an emphasis throughout the district on ecological landscaping. The latter adds distinctively to the look and feel of the neighborhood. Where greenspaces in the center strips between roads, along sidewalks, and beside homes would normally be frequently mowed and trimmed, in Romolenpolder, these areas have been allowed to grow and become largely wild. Many residents of the

Greenroofs are also beneficial in more suburban settings, such as in the Romolenpolder neighborhood in Haarlem, the Netherlands.

low-rise homes have continued this theme in their own backyard gardens, with wild assemblages of flowers and shrubs.

A number of cities promote and/or require the installation of greenroofs on new buildings. The city of Linz in Austria has one of the most extensive greenroofs programs in Europe. Under this program, the city frequently requires building plans to compensate for the loss of greenspace taken by a building. Creation of greenroofs has frequently been the response. Also, since the late 1980s, the city has subsidized the installation of greenroofs—specifically, it will pay for 35 percent of the cost. Since the program has begun, the city has spent an estimated 35 million shillings (nearly US $3 million) on this subsidy. The program has been quite successful, and there are an estimated 300 greenroofs scattered around the city. They have been incorporated into many different types of buildings, including a hospital, a kindergarten, a hotel (e.g., the Ramada Inn), a school, a concert hall, and even the roof of a gas station. Linz's experience suggests that these new areas can be seen as an important element in promoting urban biodiversity. A recent analysis of a number of the Linz greenroofs found that they harbor a high degree of biodiversity. A number of other cities, especially in Germany, have similar roof garden programs and have in place similar combinations of financial subsidies and regulations requiring them.

Greenroofs have been slower to make their way into British building designs but are now becoming popular there as well. Recent examples of new buildings that incorporate extensive greenroofs can be cited there, including a housing project in Brighton, the London Wildlife Trust's Visitor Center, the Scottish Widows Insurance Company, the Sainsbury Center for the Visual Arts at the University of East Anglia, and a new addition to the offices of the Women's Pioneer Housing Association, among others. Extensive greenroofs can be found on a wide range of building types now, including schools, a community center, a new theatre and arts center, and a new bus station. Several new British companies offer greenroof design and installation services. One company is utilizing a new installation technique called *hydroplanting* (or "spray greening"). Under this system, "Seeds, nutrients and a soil substitute are mixed together into a kind of gel and then sprayed directly onto the roof" (Letts, 1998).[2]

Greenwalls and Green Streets

There are many other positive and creative examples in European cities of efforts to green existing and new buildings, including balcony gardens, greenwalls, nestboxes, and other habitat enhancements, as well as greenroofs. (For a discussion of many of these examples and a review of the benefits and technical aspects, see Johnston and Newton, 1997). European cities and towns offer many other examples of creative urban greening. Greenwalls are especially common in German cities, and increasing efforts are made to design structures such as outside stairwells of apartment buildings and parking garages with trellises and vine-climbing frames to provide space for clinging plants. Common species used include Virginia creeper and wisteria. Interestingly, greenwalls provide many of the same benefits as greenroofs. Although our tendency in the United States is to view ivy and other wall clinging plants as destructive to building facades, their effects are generally just the opposite: wall vegetation shields against UV rays, provides shading and cooling during summer months and insulation during winter months (as much as 30 percent, according to Johnston and Newton, 1997), and provides protection against chemical weathering. Health benefits of greenwalls include the filtering of air pollutants, the minimizing of noise, and positive humidifying effects. Spitthover (cited in Kennedy and Kennedy, 1997) cautions, however, that the presence of "deep crevices and fissures," and high moisture, can lead to root damage. "A completely intact surface is thus an absolute requirement for planting with genuine climbers such as ivy and Virginia creeper" (p. 49). As Spitthover notes, it is important to choose carefully the type of vegetation planted. Deciduous plants such as Virginia creeper are appropriate for south or

southwest facing walls, where shading in summer is desired but heat gain during the winter months is also desired. On north facades, shade-tolerant, evergreen climbers are more appropriate.

The visual benefits, of course, are tremendous, and as with greenroofs, there may be significant ecological benefits too (e.g., providing important habitat for birds and insects). (Kohler, 1998, as cited in Johnston and Newton, 1997). Policy in a number of European cities, including Kassel, Munich, Berlin, and Frankfurt, supports the installation of greenwalls (Johnston and Newton, 1997). Numerous examples of greenwalls can be found in the study cities, some planned but many that appear to have emerged naturally over many years. These examples include the entire wall of a factory building in Dunkerque. Ivy is now being designed into some buildings from the start. A recent example is a new police station in Leusden, in the Netherlands. Not only is the ivy seen to provide important protection from weather and the creation of a new biotope, but it is also viewed as a measure to prevent graffiti (Government Buildings Agency, 1997).

Green Courtyards and Ecological Living Spaces

Many of the newer development projects visited and studied by the author demonstrate a remarkable ability to create greenspace—often quite wild and untamed—at the same time that fairly high densities are achieved. A number of examples can be cited, including, for example, the interior courtyard space of the Fredensgade ecological urban renewal project in Kolding (Denmark), which includes an extensive play area and a flow form/stream that constantly pumps and circulates recycled water from the project. The lake and surrounding environment at Ecolonia (in the Netherlands) provides similar benefits. The Het Groene Dak project in Utrecht (in the heart of the city) involved the reconfiguring of the housing to create a wild interior courtyard space, which includes a pond, a common house, and other amenities. Interestingly, residents of the surrounding neighborhoods are rumored to have complained that the development was permitted more greenspace than their own projects. According to city staff, this is not the case at all, but Het Groene Dak's design simply seems to contain more greenspace because of its efficient placement and spatial organization. These projects, it should be emphasized, are at considerably high densities. Kennedy and Kennedy (1997), in their study of European ecological settlements, observe the positive qualities of many of these projects for children and the provision of impressive natural play spaces:

> Ecological settlements with diverse automobile-free open areas offer an ideal opportunity to develop this kind of play environment around the residences—alleys, paths, courtyards, lawns, and spaces surrounding tenant gardens and community facilities—constitute a coherent play scape, which no longer requires any need for specially designed playgrounds. Individual activity and creativity is enhanced by further ecological measures like the rainwater collecting ponds at "Ecolonia." . . . If there is an opportunity, children will play in or around water. Puddles, hoses, pumps, and the like are welcome play opportunities, especially in combination with sand and mud.
>
> In contrast to conventional settlement projects which are often marked by an unnecessarily high degree of sealed surfaces and "manicured" green spaces, which hardly enhance children to play. On the other hand ecological settlement projects have play areas, which are usually characterized by minimum paving, plenty of vegetation, and porous surfaces, e.g., gravel areas with spontaneous vegetation, rather than by "manicured" landscaping. (pp. 45–46)

One of the most impressive design features of the Het Groene Dak is its greywater treatment system. Reusing greywater from ten of the homes, once it goes through a settling and aeration process, it is pumped to a surface reedbed for final filtration (and then sent to a pond in an interior courtyard for percolation back into the ground). Creatively, this reedbed composes an entire side of one of the project's buildings, in effect utilizing space to create an element of ecological infrastructure where turfgrass or other typical landscaping would be placed. This reedbed, then, has become a prominent visible element in the project, hard to miss by those walking by on the adjacent sidewalk (see photo).

Many municipalities financially support the development of these kinds of green-urban features. The city of Vienna, for instance, has for many years provided financial subsidies for greening courtyards. Started in 1982, the Green Courtyards program has resulted in green improvements in more than 2,400 courtyards (by 1990; City of Vienna, 1992).

Eco-Bridges

Another greening strategy is to build ecoducts or ecobridges that seek to tie together urban habitats. The Dutch have a history of building impressive eco-bridges that provide natural connections passing over highways and roads. The Dutch Rijkswaterstaat (water management agency) has been,

since 1998, building wildviaducts—wildlife viaducts or highway overpasses—in the Veluwe region. Studies suggest that these green viaducts do work in practice, with wildlife using them (e.g., the wildviaduct Woeste Hoeve; see TROS video, 1998).

Other notable examples of the use of wildviaducts or "ecoducts" in the Netherlands include a wild connection across the A-1 near Kootwijk (50 meters across), one in the Midden-Brabant area connecting two nature parks, and important wildviaducts across the A-50, near Arnhem. These bridges and ecoducts are not without controversy. First, they can be fairly costly to build: for example, the A-1 ecoduct cost about 6 million guilders (US $3 million to construct). Some in the natural and biological community question ecoducts' ability to actually enhance nature, noting that in some cases the wildviaducts provide connections that do not lead to significant areas of habitat, and that the general trends (these efforts at building ecoducts notwithstanding) are in the direction of declining nature (see Brabants Dagblad, 1997; Rigter, 1997).

Other more urban examples can be found. In the new Utrecht (the Netherlands) growth district of Leidsche Rijn, dramatic plans are to move and "cap" the A-1 highway for a length of 2 kilometers. This strategy of highway roofing will allow pedestrian and bicycle connections to the center of Utrecht for the 30,000 new residents. This is a bold plan that will create new land and overcome the typical spatial obstacles presented by major roads and highways (see Gemeente Utrecht, undated; 1992). More Dutch and European cities will likely be doing this in the future.

City Farms and Ecology Parks

Other creative examples of injecting nature into the city include the creation of *ecology parks* (as in London) and *city farms* (municipal-owned farms, often on the outskirts of cities, for educational functions) (see Goode, 1989).

Many of the cities studied own and operate working farms—city farms—that serve a variety of recreational, educational, and other benefits. In many ways, this is a distinctively European idea. The city of Göteburg, for example, owns sixty farms, encompassing some 2,700 hectares of land. The land, acquired as sites for future urban expansion, is currently utilized for a variety of agricultural and recreational purposes (the bigger properties are leased to farmers). A number of the smaller farms are open to the public and are utilized for a variety of social functions. Examples include public stables, pick-your-own berry and vegetable farms, a visiting or petting farm, and a riding stable for disabled persons, among others (City of Göteburg, undated). Another example, the Aspö city farm in Skörde, Sweden, was established adjacent to several residential areas. Its workings are detailed in the *European Sustainable Cities* report:

> The city farm has cows, pigs, chickens, and small fields of grain and other crops. Day nursery and school classes frequently visit the farm, and everyone interested may join in the work. Children can help look after the animals, although the animals are sent to the slaughterhouse as with normal farming practice. The services of a farmer are hired for the management of the farm, and a recreational teacher is hired to lead the study tours and other activities. The farm makes a small profit.

Countries like the United Kingdom have their own well-developed network of city farms, and even a National Federation of City Farms, located in Bristol, with sixty members. Typically, these farms receive core funding from local governments, but they are also required to supplement these funds through the sale of agricultural goods and products. City farms are often tucked in between development and in fairly urban environments. The Freightlines farm in Islington Burough illustrates the important role such parks can play in an urban setting. Some 40,000 visitors come to this farm yearly. A variety of workshops, tours, and educational programs are offered, largely aimed at schoolchildren. It is also a commercial working farm, supplying eggs, honey, and other products to local residents. Farmyard manure is also sold for yard use to local residents (Farmers Weekly, 1998).

Dutch cities have been particularly effective at integrating city farms into new development. Small areas of pasture, livestock, and farm buildings are often sited at the core of green areas around which housing is clustered. Good examples can be seen in Leiden in the Stevenshof and Merenwijk neighborhoods.

Ecology parks have been created in United Kingdom out of small areas of leftover land, often former industrial or previously developed lands. Such parks typically entail the restoration of habitat along with the creation of an educational center and environmental education programs aimed at urban schools and children. One recent example in London is the establishment of an ecology park in the docklands area (see Lucas, 1994).

Green Schools

Another promising idea found in European cities is the notion of greening of schools. Several examples can be found of efforts among the study cities to make schools and school grounds more green and to take advantage of the opportunities to promote environmental education there. Zürich, for example, has been implementing a *Nature around the schoolhouse* project, including measures to educate students about environment in the city, to

change the way school grounds are managed, and in certain cases to "structurally redesign" schoolhouses (Berger and Borer, 1994). The last measure includes actions to break up and take out impervious surfaces around the schools and to plant trees and vegetation. Nine schoolhouses so far have undergone this form of restructuring, and another forty have had special core measures applied. The students in these schools have been directly involved in carrying out these changes.

The schools built in the new development area of Nieuwland, in Amersfoort, also include some interesting measures for educating and involving students. De Wonderboom primary school, for instance, includes both a greenroof and extensive photovoltaic panels. As a result of extensive daylighting in the design, students can, through an interesting mirror system, directly see and monitor the greenroof. In the main entrance to this school, moreover, is an energy panel, which allows students (and teachers) to see daily, monthly, and yearly energy consumption as well as the production from the photovoltaics.

Desealing and Natural Drainage Strategies

Many European cities are working hard to minimize the presence of concrete and hard surfaces. Berlin has been implementing a program to deseal or remove concrete and paved surfaces throughout the city. Under its landscape plan, the city has spent DM 30 million over twelve years (about US $16 million) to remove pavement and plant vegetation. This has taken place on some 1,400 sites in the city.

Saarbrücken has one of the most interesting programs for encouraging green development in the city, particularly aimed at rainwater management. The city's program for encouraging rainwater retrieval and percolation is literally translated "rainwater is so valuable for the canal" (*"Regenwasser ist zu kostbar für den Kanal!"*) (Landeshauptstadt Saarbrücken, 1997). It is actually part of a broader program of the German Länd (state) of Saarland. Saarland has made several million deutsche marks available to communities, and some fifty communities have developed programs. Saarbrücken's program is essentially one of providing small financial subsidies for citizens (and businesses) who wish to undertake some sort of project or action that conserves water and reduces stormwater runoff.

Specifically, these proposed actions can qualify for grants from DM 5,000 to DM 10,000 (US $2,700 to US $5,400) for one of several types of actions: (1) projects for collecting and using rainwater in or around the home, for example, for toilet flushing or plant watering, (2) projects for desealing, or taking up impermeable pavement and replacing it with vegetation or permeable bricks, and (3) the installation of greenroofs. The

actual grant award is based on a per square meter calculation, ranging from DM 15/square meter (about US $8) for rainwater use (based on the area of the rooftop) to DM 30/square meter (about US $16) for desealing and rainwater diversion projects, to DM 60/square meter (about US $32) for installing a greenroof. Desealing projects qualify for a maximum DM 5,000 grant (about US $2,700) and greenroofs for a maximum DM 10,000 (about US $5,400), the highest award. The program, although only in its second year, has been quite popular with the public.

About forty projects have been funded so far, most for rainwater using and desealing and just a few for the installation of greenroofs. The municipality's environment department has received a great many requests for information about the program. In the first year, it had about DM 100,000 to distribute (about US $54,000), with the goal of spreading it around in small amounts for a number of different projects. In most cases, the grants do not cover the entire cost of the proposed action or project, and it might be wondered whether the funds are going to pay for improvements that homeowners might be planning to undertake anyway. However, there is good indication that the program, even though the grants are not large and the number of participants is currently small, does have an important catalytic effect in encouraging these kinds of greening and ecological investments. Interestingly, the administrator of the program believes that interest in the program is not driven so much by stronger environmental ideology as a genuine interest in making homes nicer. She believes that even greater interest will result when, in the near future, the Stadtwerke begins to charge residents not only for wastewater but also for the stormwater generated from one's property.

In many projects, rainwater collection and use, greywater recycling, and water conservation are key design elements. The GWL-terrein project in Amsterdam, for example, is making extensive use of rainwater for toilet flushing. In combination with water-conserving toilets, very little water is used for flushing (only 4 liters per flush, compared to 9 to 10 liters for an average Dutch toilet). Rainwater is collected from rooftops, stored in cisterns, and used for toilet flushing. A float mechanism triggers a filling up of the cisterns with tap water when they become too low.

There are many examples in these cities of projects incorporating natural drainage as a key design element. The Dutch now frequently utilize what they call *wadies*—or natural drainage ditches—and these are key ecological features in a number of recent residential projects. In *Oikos,* an ecological project in Enschede, the wadies are a main feature. Here, instead of conventional storm sewers, water is directed into these green swales from sidewalks and rooftops. Within these linear swales is a perforated drainpipe, surrounded by a fabric cocoon of clay pellets. The pellets actually

accommodate the growth of bacteria, which provide a treatment function for collected stormwater. In the Enschede area, groundwater levels have been gradually declining, with serious impact on heather plant communities. So, in this western region of the Netherlands, there is special emphasis on allowing as much groundwater percolation as possible.

Much of the parking in *Oikos* is in the form of permeable bricks, which allow water to percolate into the ground and a green carpet of grass to grow around the bricks. Creatively, roof spouting guides water across the sidewalks to these permeable parking and street spaces. Project planners like the notion that residents can see directly what is flowing into these wadis and permeable spaces. (In the past, problems have arisen from residents pouring unwelcome things down the storm drains.) In a central area in the development, a common car-washing area has been created. Here, the water from washing cars does not go into the wadis (and thus into the groundwater), but into the city's sewage system for treatment instead. Rainwater is used for this purpose and is collected and stored in an underground cistern. The washing pump is solar powered.

Planning for Local Climate

There is a much greater sense by the cities in this study of their climatological and meteorological context and the need to manage development and growth in ways that protect favorable climatic conditions.

A detailed climate study serves as a major environmental basis for the land use plan for Graz (Stadtklimaanalyse Graz), for example. This city has pollution problems that are the result of a combination of topographic conditions (700-meter mountains immediately to the west of the city; hills to the east), and inversions that occur in certain months of the year. Climatopes and wind circulation patterns have been extensively mapped, and problem areas identified. Policies flow directly from these conditions, including mandating that certain areas of the city must convert to the city's district heating network by a certain date, as well as the preparation of a new landscape plan that will better protect greenspace in and around the city.

Berlin also experiences higher-than-normal urban temperatures in summer and views its regional landscape as an important factor in addressing this situation. (see City of Berlin, 1996). Berlin's woodlands—comprising 18 percent of its land area—are seen as important "climate lanes," allowing for the flow of cool air into the city during hot conditions. Under the city's Landscape Programme, "climate protection priority areas" are delineated, which must be protected, as well as problem areas where greening

and removal of concrete and asphalt surfaces should occur. Climate zonation is also used in the Heidelberg and Münster plans.

Freiburg's planning also reflects a strong concern about protecting positive local climatic conditions. Specifically, it tries to prevent obstruction to the cool winds that flow down each evening from the Black Forest. The city implements a concept of *transparent construction,* requiring buildings in certain wind zones to be designed (with the use of a university wind model) to allow winds to flow through. The city's new soccer stadium, for example, was designed and oriented to allow this.

Saarbrücken prepared and published its first climate zone plan in 1997. It looks like many similar plans that identify important dynamic processes and climate zones in the city (the larger regional jurisdiction has prepared a similar map), barriers to air movement, forests, and other climatically important areas. The map and plan are the bases for making climate-friendly land use decisions. In particular, the stream valleys leading into the city (which represent important fresh air flows) and the agricultural areas to the west of the city are viewed as important climate regulation zones. Most of these areas have now been placed off limits for development in the city's development plan.

Ecological Regeneration

There are also examples of cities that have undertaken serious and substantial ecological restoration or regeneration work. The city of Leicester, for example, has taken extensive actions to restore the river corridor that runs through the city. Riverside Park, a 2,400-acre, 12-mile-long park, has been created out of what was largely derelict land in the early 1970s. Under the Leicester Ecology Strategy, and through partnerships with organizations such as British Waterways, the National Rivers Authority, and the Countryside Commission, as well as with landowners, significant resources have been directed to restoring and cleaning up the corridor. Riverside Park has now become one of the city's most important ecological and recreational resources (see Environ, 1996).

A number of cities are attempting to restore the natural qualities of streams and creeks, many of which had been channelized or put underground. Such programs exist in Zürich and Heidelberg, for example. In Zürich, some 100 kilometers of streams have been placed underground and "canalized." Zürich has embarked on a program to eventually open up, or bring to the surface, 40 kilometers of these streams, and it has already done this for 25 kilometers (Villiger, 1989). The placement of these new "opened" streams is based on historical records of where the streams orig-

inally existed, a route where they can be kept open and unbroken, and where they tie into and connect with existing footpaths and open spaces. The resulting streams are intended to accommodate native trees and vegetation and contribute to the greenness of urban areas. As Villiger (1989) describes their purpose:

> On their way down from the wooded hilltops into the valleys, the streams have a linking and structuring function. Together with the appurtenant vegetation, they can have a noticeable effect on the climate, bringing fresh air into the built-up area along their line of descent. Provided they have an almost natural bottom and do not descend in a step-like manner, they can accommodate a rich flora and fauna. (p. 8)

Ecological Urban Restructuring

One of the most interesting model projects for greening the urban environment, yet to be implemented, was prepared for the former East German city of Leipzig. An effort to demonstrate the concepts of "ecological urban restructuring," the model project was the brainchild of Ekhart Hahn and was funded through the European Union program LIFE. The project sought to "green" a major slice or cross section of the city—specifically its eastern district (Leipzig Ostraum). A central design element was to be the creation of a *Green Radial,* which would connect the surrounding countryside with the very center of the city, specifically an abandoned railyard (the Eilenburger Bahnhof) (Hahn and LaFond, 1997). The two-kilometer radial would be redesigned to include bicycle paths and pedestrian greenspaces (connecting city and countryside) and recreational facilities.

Mixed-use new neighborhoods would surround the radial and would be greened through new community gardens, recycling and composting facilities, and other "ecological restructuring." A new residential ecological community is envisioned, and connections at the edge are to be made with an organic farm and municipal farms, which will grow and market local ecologically produced agricultural products. In about the middle of the Green Radial would be an innovative neighborhood ecological center—dubbed an "ecostation." To be housed in a former locomotive barn, the ecostation would be the center of energy and activity, a place where ecological training and workshops could be held, where equipment and tools could be borrowed, where public meetings and conferences could take place, where information about ecological services and products could be found, and where a variety of ecological demonstrations could occur. More specifically, Hahn and Lafond list some of the likely activities and functions to be served by the ecostation (Hahn and LaFond, 1997, p. 46):

- Exhibition, seminar, and event spaces
- Environmental library with reading cafe
- Natural foods restaurant with ecological nutrition counseling center and teaching kitchen
- Coordination office for "Local Agenda 21"
- Information and advice for ecological neighborhood renewal
- Energy office for implementation of neighborhood-based energy concepts
- Water and waste agencies
- Mobility service bureau (car-sharing, car-pooling, bicycle center with rentals and self-help workshop, coordination of "Job-ticket" concepts, support of "auto-free" communities, etc.
- Environmental measurement station for taking and analyzing readings of air, water, and soil quality
- Information regarding "municipal farms" and rural initiatives
- Green Workshop for the practical realization of the Green Radial.

While the Leipzig demonstration met with certain difficulties, and the Green Radial concept and the ecostation have not yet been implemented, these ideas represent powerful new ways of reconsidering the spatial relationships between city and countryside.

Urban Gardens

Many of the European cities studied here maintain extensive allotment gardens—areas of small garden plots, rented or assigned to the general public and used for recreational flower and food gardening. There is a long tradition of allotment gardens in Europe, and they are a significant element of green in many of the European cities. Extensive allotment gardens exist, for instance, in Copenhagen, Amsterdam, and Berlin (80,000 in Berlin alone with some 16,000 on a waiting list), and these further contribute to providing greenspace and improving the quality of life experienced by residents (United Nations Development Programme, 1996). Some cities have been gradually expanding these gardens. Freiburg has about 4,000 *Kleingarten* (small gardens), adding another 300 or 400 per year. (There is also currently a waiting list there.)

An important and consistent feature in many of the new development areas planned in these European cities is the provision made for new allotments or community gardens. Indeed, perhaps a reflection of the historical

importance of such gardens, even very urban sites are making provisions for them. In Helsinki, the Viikki ecological neighborhood, for example, envisions the creation of a horticultural center that will "rent out allotments to residents, give information, lend and hire gardening tools and maintain model plots" (City of Helsinki, undated, p. 4). In the design of Oikos, an ecological housing project in Enschede (Netherlands), a series of community gardens interspersed throughout the residential areas is a main feature of the project's masterplan. Similarly, much of the interior space of the GWL-terrein project in Amsterdam is organized in the form of allotment gardens.

Urban Wildlife and Habitat Conservation

The case cities also provide good examples of efforts to identify important areas of wildlife habitat in and around cities and to protect and enhance these areas. For many of the study cities, extensive biotope and habitat mapping and protection programs have been established. In London, many of the boroughs have prepared detailed habitat studies and plans. There has been a significant effort to protect important nature and habitat sites in the London area. Beginning in the 1980s, and with the biological and technical assistance of the London Ecology Unit, individual boroughs prepared nature conservation strategies and incorporated these into their Urban Development Plans (UDPs). Today, nineteen boroughs have published strategies, with another six strategies in preparation (of thirty-two boroughs). At the heart of these strategies is a system for mapping and classifying local natural areas, as well as for identifying areas of nature deficiency (spatial gaps where it is farther than a kilometer to a nature site). Local sites are classified according to whether they are of metropolitan significance, borough significance, or local significance (see, for example, Yardham, Waite, Simpson, and Machin, 1994).

Local borough plans (where these strategies have been prepared) incorporate these designations, and, according to David Goode, director of the London Ecology Unit, are generally placed off limits to development (although the loss of some brownfield or derelict sites has occurred through redevelopment). The most recent nature conservation effort has been the initiation of a new London Biodiversity Partnership, bringing together a diverse array of groups and actors and land users to develop a strategic action plan for preserving habitat and species in Greater London (many other local jurisdictions are or will be preparing Biodiversity Action Plans in the United Kingdom).

Leicester was one of the first cities in the United Kingdom to develop a comprehensive ecology strategy. As a first step, it conducted an extensive, and at the time unusual, Habitat Survey. The survey rated all

vacant lands and sites in the city (including such areas as churchyards and garden allotments) according to their habitat value, applying a letter grade to each. Some 1,800 sites were surveyed and classified. The result was a truly impressive, comprehensive picture of the extent and quality of habitat within the city (Leicester City Council, 1989). The survey's results show an urbanized environment with considerable wildlife and important natural habitat, including "189 miles of linear habitats, such as the canal, rivers, streams, railways, road verges and hedgerows, which provide homes and corridors for a great variety of wildlife" (p. 19). This survey and classification led to the development of the Leicester Ecology Strategy. The strategy identifies ways in which this urban ecology can be protected and restored and sets forth a series of ecology policies for the city, as well as more detailed conservation and management proposals for various areas and parts of the city. For example, policy E2 states that the council will define and protect "a 'green network' of wedges, corridors, and other vegetated areas and features, so as to conserve an integrated system of wildlife habitats and will resist development of these sites" (Leicester City Council, 1989, p. 59). These habitat protection goals and targets have been incorporated into Leicester's land use plan and are reflected in specific initiatives, such as Riverside Park, which was discussed earlier.

In Bologna, the province has developed an exemplary plan that delineates natural and sensitive lands. Protected areas include natural parks (there are five in the province), rivers (including a zone of 150 meters on either side), and hills and woods. Most of these areas have strong protection and are generally off limits to development.

Many German cities, including Berlin and Heidelberg, have had comprehensive biotope mapping initiatives (see Sukopp, 1980). Heidelberg has taken a number of, albeit small, actions to construct new habitat (e.g., new parks and lakes for amphibians; bat habitat). The city is also subsidizing farmers to maintain and restore certain habitat types, and it operates a "rent-a-sheep" program, which helps to maintain certain grassland habitats (and also provides jobs for the unemployed in the city). These are but a few examples of a rich set of ideas and strategies for greening and naturalizing European cities.

Lessons for American Cities

Urban environments can and must become more fundamentally green and natural. Cities ought to be, as discussed in Chapter 1, like forests—enhancing, improving, and restoring the natural environment and condition of cities. These European cities (and countries) taken together provide a tremendous variety of creative and inspirational ideas for greening the