Literature Supporting Claims Regarding the Environmental Ecosystems Services Benefits of Green Industry Products (flowers, shrubs, trees, etc.)

Listed in chronological order

Radford, K. G. and P. James (2013). "Changes in the value of ecosystem services along a rural–urban gradient: A case study of Greater Manchester, UK." Landscape and Urban Planning 109(1): 117-127.

The degradation and loss of vital ecosystem functions and services have been an uncontested result of urbanisation. An understanding of how ecosystem services are provided along rural–urban gradients is crucial in the task of conserving and enhancing vital services in urban environments, increasing the quality of life of urban dwellers, and working towards a sustainable future. Focusing on nine ecosystem services – aesthetic, spiritual, recreation, water flow regulation, carbon sequestration, climate change adaptation, pollination, biodiversity potential, and noise attenuation – regarded as important to urban areas the authors detail the changes in the values of these services along a gradient comprising four categories of urbanisation: urban, suburban, peri-urban and rural, in Greater Manchester, UK. The data on which the discussion is based are derived from an interdisciplinary assessment tool, developed from a selection of previously used assessment methods including the Residential Environment Assessment Tool and the Green Flag Award. Based on a mixture of a field and desktop study, the new tool assigns non-economic values of 0–10 to the selected services, allowing for evaluation of quality between, as well as within, each category of ecosystem service. Trends in the results are discussed, as are drivers for the changes in values along the rural–urban gradient. It is foreseen that this new body of knowledge will allow both practitioners and academics to gain further insight into the provision of ecosystem services along a rural–urban gradient to allow them to tackle the problems associated with them and to optimise open space planning.

Jungels, J., et al. (2013). "Attitudes and aesthetic reactions toward green roofs in the Northeastern United States." Landscape and Urban Planning 117(0): 13-21.

Green roofs may provide environmental, aesthetic, and social benefits. Their environmental benefits have been the subject of considerable research in the past decade; the aesthetic and social aspects, however, have received less attention. Some authors have questioned the visual appeal of some green roof designs. Nonetheless, little research has examined aesthetic reactions toward green roofs or attitudes concerning them. We conducted visitor surveys at seven green roofs in the Northeastern US to assess visitors' aesthetic reactions to different types of green roofs, determine general attitudes toward green roofs, and assess values concerning benefits and costs associated with them. Attitudes toward green roofs were positive with higher importance being placed on green roof benefits than costs. Aesthetic reactions were, in general, positive. Aesthetic reactions to roofs dominated by stoloniferous grasses were more negative than to either sedum-dominated or mixed perennial roofs. Principle component analysis showed that negative aesthetic reactions were associated primarily with a perception of messiness. Furthermore, respondents felt that the grass-dominated roofs blended less well with the building and surrounding landscape. Aesthetic reactions were positively correlated with attitudes and importance placed on the benefits of green roofs. Positive visitor reactions to sedum-dominated extensive roofs is a favorable result for the green roof industry as these are the most common type of green roof and this suggests that there is high promotion potential if more of these roofs are designed to be visible from street level.

Hubacek, K. and J. Kronenberg (2013). "Synthesizing different perspectives on the value of urban ecosystem services." Landscape and Urban Planning 109(1): 1-6.

Giner, N. M., et al. (2013). "Understanding the social determinants of lawn landscapes: A fine-resolution spatial statistical analysis in suburban Boston, Massachusetts, USA." Landscape and Urban Planning 111(0): 25-33.

This study examines the influence of social processes on the spatial distribution of residential lawns, one of the most prominent anthropogenic environmental challenges in US urban/suburban areas today. Specifically, we examine how three theoretically informed social drivers of urban vegetation patterns—population density, social stratification, and lifestyle behavior—explain two measures of residential lawns at the US Census block group (CBG) scale in suburban Boston, MA, USA. Using fine-spatial resolution (0.5 m) remotely sensed data, we map land cover from which we generate two lawn measures: (1) “percent lawn cover,” which is the overall percentage of land in a CBG containing lawn, and (2) “percent lawn realized stewardship,” which is the percentage of non-developed land in a CBG containing lawn. We use spatial regression to find that population density and lifestyle behavior, proxied by percentage of single-family detached homes, average household size, and percentage of protected land in the CBG—are the key social processes driving the spatial distribution of both lawn measures in our study area. Results also show that spatial regression provides theoretical insight into additional, unspecified processes influencing the spatial distribution of lawns, net of the effects of the independent variables. These findings contribute to the existing understanding of the social processes influencing the residential lawn landscape, and are therefore useful for scientists, decision-makers, and stakeholders who are interested in moderating the potential social and ecological impacts of this landscape.

Strohbach, M. W., et al. (2012). "The carbon footprint of urban green space—A life cycle approach." Landscape and Urban Planning 104(2): 220-229.

Cities play an important role in the global carbon cycle. They produce a large proportion of CO2 emissions, but they also sequester and store carbon in urban forests and green space. However, sequestration by urban green space is difficult to quantify and also involves emissions. The carbon footprint analysis is an established method for systematically quantifying carbon sinks and sources throughout the lifetime of goods and services. We applied this method to an urban green space project in Leipzig, Germany. To the best of our knowledge it is the first application in this field. We simulated carbon sequestration by growing trees and contrasted it with all related carbon sources, from construction and maintenance over the lifetime of 50 years. In addition, we explored alternative design and maintenance scenarios. Total net sequestration was predicted to be between 137 and 162 MgCO2 ha−1. Park-like design and maintenance is less effective than forest-like design and maintenance. Much uncertainty is linked to tree growth and tree mortality. Increasing annual tree mortality from 0.5 to 4% reduces sequestration by over 70%. In conclusion, urban green space can act as a carbon sink and the design and maintenance have a strong influence on the carbon footprint. The carbon footprint analysis is a valuable tool for estimating the long-term environmental performance of urban green space projects. Compared to emissions from people, the overall potential for carbon mitigation is limited, even in cities such as Leipzig with widely available space for new urban green space.

Strohbach, M. W., et al. (2012). "Erratum to “The carbon footprint of urban green space—A life cycle approach” [Landsc. Urban Plann. 104 (2012) 220–229]." Landscape and Urban Planning 105(4): 445.

Gupta, K., et al. (2012). "Urban Neighborhood Green Index – A measure of green spaces in urban areas." Landscape and Urban Planning 105(3): 325-335.

Urban green spaces (UGS) form an integral part of any urban area and quantity and quality of UGS is of prime concern for planners and city administrators. Objective measure of greenness using remote sensing images is percentage area of green, i.e., Green Index (GI), which is insensitive to spatial arrangement within the areal units. Measuring UGS at neighborhood level is important as neighborhood is the working level for application of greening strategies. Neighborhood (NH) is synonymous of nearness and can be defined as an area of homogeneous characteristics. The Urban Neighborhood Green Index (UNGI) aims to assess the greenness and can help in identifying the critical areas, which in turn can be used to identify action areas for improving the quality of green. For the development of UNGI, four parameters, i.e., GI, proximity to green, built up density and height of structures were used and weighted using Saaty's pair wise comparison method. Four different types of NH were compared and it was found that mean GI (0.44) is equal for high-rise low density and low-rise low density NH, i.e., both areas have same quality of urban green based on GI. But mean UNGI is higher for low-rise low-density NH (0.62), as compared to high-rise low-density NH (0.54), hence, area of highrise NH requires more amounts of good quality properly distributed green as compared to low-rise NH. The input for UNGI is easily derivable from RS images, besides the developed method is simple, and easily comprehendible by city administrators and planners.

Zheng, B., et al. (2011). "Preference to home landscape: wildness or neatness?" Landscape and Urban Planning 99(1): 1-8.

This study explores students’ preferences toward natural and wild versus clean and neat residential landscapes using preference survey data. Based on the rating scores of four housing landscape designs, multinomial logit models were used to explore the potential influential factors on people's preferences, especially the wildness or neatness of the home landscape. The results suggest that students in agricultural economics, horticulture, and social sciences are more inclined to choose a neat, well-kept environment around their homes. In contrast, wildlife science students prefer more natural landscapes. This study also found that senior students and students from large cities also prefer well-maintained and artificial landscapes. Also, students who are members of an environmental group, and those whose parents have a better education, are more likely to choose a more natural landscape. The results would provide additional information for planners, developers, engineers, architects and foresters in building more livable communities which are aesthetically appealing but also ecologically sound.

McPherson, E. G., et al. (2011). "Million trees Los Angeles canopy cover and benefit assessment." Landscape and Urban Planning 99(1): 40-50.

The Million Trees LA initiative intends to improve Los Angeles's environment through planting and stewardship of 1 million trees. The purpose of this study was to measure Los Angeles's existing tree canopy cover (TCC), determine if space exists for 1 million additional trees, and estimate future benefits from the planting. High-

resolution QuickBird remote sensing data, aerial photographs, and geographic information systems were used to classify land cover types, measure TCC, and identify potential tree planting sites. Benefits were forecast for planting of 1 million trees between 2006 and 2010, and their growth and mortality were projected until 2040. Two scenarios reflected low (17%) and high (56%) mortality rates. Numerical models were used with geographic data and tree size information for coastal and inland climate zones to calculate annual benefits and their monetary value. Los Angeles's existing TCC was 21%, and ranged from 7 to 37% by council district. There was potential to add 2.5 million additional trees to the existing population of approximately 10.8 million, but only 1.3 million of the potential tree sites are deemed realistic to plant. Benefits for the 1-million-tree planting for the 35-year period were $1.33 billion and $1.95 billion for the high- and low-mortality scenarios, respectively. Average annual benefits were $38 and $56 per tree planted. Eighty-one percent of total benefits were aesthetic/other, 8% were stormwater runoff reduction, 6% energy savings, 4% air quality improvement, and less than 1% atmospheric carbon reduction.

Dobbs, C., et al. (2011). "A framework for developing urban forest ecosystem services and goods indicators." Landscape and Urban Planning 99(3-4): 196-206.

The social and ecological processes impacting on urban forests have been studied at multiple temporal and spatial scales in order to help us quantify, monitor, and value the ecosystem services that benefit people. Few studies have comprehensively analyzed the full suite of ecosystem services, goods (ESG), and ecosystem disservices provided by an urban forest. Indicators, however, are one approach that could be used to better understand the structure of an urban forest, the suite of ESG provided by urban forests, and their influence on human well-being using a simple, innovative and repeatable metric. This study presents a framework for developing indicators using field data, an urban forest functional model, and the literature. Urban tree and soil indicators for groups of ecosystem functions were used to statistically analyze the effects of urban morphology and socioeconomics on urban forest ESG. Findings show that the most influential ESG indicators were tree cover, soil pH, and soil organic matter. Indicators were significantly influenced by land use and time since urbanization, while analyses of property values and household income did not yield any particularly significant results. The indicators presented in this paper present a first approach to non-monetary valuation of urban forest ESG and can be used to develop urban forest structure management goals and to monitor the effects of urban greening policies on human well-being.

Wolf, K. L. and L. E. Kruger (2010). "Urban Forestry Research Needs: A Participatory Assessment Process." Journal of Forestry 108(1): 39-44.

New research initiatives focusing on urban ecology and natural resources are underway Such programs coincide with increased local government action in urban forest planning and management, adivities that are enhanced by scientific knowledge. This project used a participatory stakeholder process to explore and understand urban forestry research and technology transfer needs in the Pacific Northwest region of the United States. The approach can be readily used for any geographic region or metropolitan area. A two-phase, abbreviated Delphi process was conducted, inviting input from urban forestry professionals, academics, and agency-based managers. Research issues were identified and prioritized within three themes: urban forest resource, resource management, and community framework. The results serve as a stakeholder relevant research framework to guide science proposals for funding initiatives of regional and national levels. Notable is major support by respondents for a better understanding of the transactional dynamics of human systems and urban natural resources.

Sellmer, J. C. (2010). "Bringing Nature Home: How Native Plants Sustain Wildlife in Our Gardens." HortTechnology 20(1): 257-.

Bringing Nature Home is the first book that this reviewer has found on the market to provide a discussion on how by using native plants in the home landscape, we can support the native fauna in the garden, landscape, and surrounding community. The book consists of 14 chapters with the first seven chapters providing arguments against non-native plants. Chapters 8 through 10 begin the discussion of biodiversity and approaches for using natives in the landscape. Chapters 11 through 13 provide insight into what native plants to use to attract native insects that feed upon those plants. The final chapter provides answers to common tough questions surrounding the debate about the use of native and non-native plants in the home landscape. The appendices consist of three sections with the first listing native plants classified by type (e.g., shade and specimen trees, shrub and understory trees, conifers, vines, grasses, herbaceous perennials) with wildlife value for general regions across the country (e.g., Mid-Atlantic, Southeast, Southwest, and Pacific Northwest). Appendix two is a table of butterflies and moths and their hosts, and appendix three provides some unpublished data from the author's research on insect herbivory on woody native and alien species in his backyard and published work by his graduate student on early successional perennials.

Home, R., et al. (2010). "Cultural and Biological Determinants in the Evaluation of Urban Green Spaces." Environment and Behavior 42(4): 494-523.

Dramatically increasing urbanization is observable worldwide and brings pressure on space within urban areas as the built environment intensifies. Considerable evidence suggests that contact with nature is important for city dwellers, although it is not known whether residents' appreciation of the forms of urban green spaces is constant across different contexts. More specifically, it has not yet been shown whether our appreciation of nature is innate and inherently human, is cultural and something that we learn, or is a mixture of both. This article describes an exploratory study consisting of 17 interviews carried out in Zurich, Switzerland. Kelly's repertory grid technique is used to identify preferred urban landscapes, which were contrasted with identified rejected landscapes. Principle components analysis and multidimensional scaling reveal a clear separation of cultural and biological modes of landscape assessment in some respondents. The research contributes to an understanding of the meanings of urban green spaces, which would in turn provide planners with a tool to match urban natural resource management with the needs of residents.

Dearborn, D. C. and S. Kark (2010). "Motivations for conserving urban biodiversity." Conserv Biol 24(2): 432-440.

In a time of increasing urbanization, the fundamental value of conserving urban biodiversity remains controversial. How much of a fixed budget should be spent on conservation in urban versus nonurban landscapes? The answer should depend on the goals that drive our conservation actions, yet proponents of urban conservation often fail to specify the motivation for protecting urban biodiversity. This is an important shortcoming on several fronts, including a missed opportunity to make a stronger appeal to those who believe conservation biology should focus exclusively on more natural, wilder landscapes. We argue that urban areas do offer an important venue for conservation biology, but that we must become better at choosing and articulating our goals. We explored seven possible motivations for urban biodiversity conservation: preserving local biodiversity, creating stepping stones to nonurban habitat, understanding and facilitating responses to environmental change, conducting environmental education, providing ecosystem services, fulfilling ethical responsibilities, and improving human well-being. To attain all these goals, challenges must be faced that are common to the urban environment, such as localized pollution, disruption of ecosystem structure, and limited availability of land. There are, however, also challenges specific only to particular goals, meaning that different goals will require different approaches and actions. This highlights the importance of specifying the motivations behind urban biodiversity conservation. If the goals are unknown, progress cannot be assessed.

Bowler, D. E., et al. (2010). "Urban greening to cool towns and cities: A systematic review of the empirical evidence." Landscape and Urban Planning 97(3): 147-155.

`Urban greening' has been proposed as one approach to mitigate the human health consequences of increased temperatures resulting from climate change. We used systematic review methodology to evaluate available evidence on whether greening interventions, such as tree planting or the creation of parks or green roofs, affect the air temperature of an urban area. Most studies investigated the air temperature within parks and beneath trees and are broadly supportive that green sites can be cooler than non-green sites. Meta-analysis was used to synthesize data on the cooling effect of parks and results show that, on average, a park was 0.94 °C cooler in the day. Studies on multiple parks suggest that larger parks and those with trees could be cooler during the day. However, evidence for the cooling effect of green space is mostly based on observational studies of small numbers of green sites. The impact of specific greening interventions on the wider urban area, and whether the effects are due to greening alone, has yet to be demonstrated. The current evidence base does not allow specific recommendations to be made on how best to incorporate greening into an urban area. Further empirical research is necessary in order to efficiently guide the design and planning of urban green space, and specifically to investigate the importance of the abundance, distribution and type of greening. Any urban greening programme implemented would need to be appropriately designed and monitored to continue to evaluate benefit to human health through reducing temperature.

Bassuk, N. and P. Trowbridge (2010). "Creating the Urban Eden: Sustainable Landscape Establishment in Theory and Practice." HortTechnology 20(3): 485-486.

Creating the Urban Eden, a course taught jointly by faculty in Landscape Architecture and Horticulture at Cornell University, is a unique two-semester class spanning the academic year from August to May. Students face the task of creating viable, sustainable landscapes both in theory and practice. The success and sustainability of any planting design is ultimately dependent upon knowledgeable site assessment and analysis, appropriate plant selection, and clear communication of design intentions. This class teaches all aspects of landscape establishment, including detailed site assessment, woody plant identification, choice of appropriate plants, planting design, soil remediation, transplanting, and early maintenance in human-impacted landscapes. In addition to designing for a specific site, students learn about written specifications for technical planting and graphic details to communicate and implement design proposals. Every year on the Cornell University campus, the students in this class implement, in a hands-on manner, all aspects of landscape establishment that they have learned by creating new landscapes that serve to integrate theory, principles, practice, and provide a demonstration of fundamentals taught in the class.

Yang, D. S., et al. (2009). "Screening Indoor Plants for Volatile Organic Pollutant Removal Efficiency." HortScience 44(5): 1377-1381.

Twenty-eight ornamental species commonly used for interior plantscapes were screened for their ability to remove five volatile indoor pollutants: aromatic hydrocarbons (benzene and toluene), aliphatic hydrocarbon (octane), halogenated hydrocarbon [trichloroethylene (TCE)], and terpene ({alpha}-pinene). Individual plants were placed in 10.5-L gas-tight glass jars and exposed to {approx}10 ppm (31.9, 53.7, 37.7, 46.7, and 55.7 mg{middle dot}m-3) of benzene, TCE, toluene, octane, and{alpha} -pinene, respectively. Air samples (1.0 mL) within the glass containers were analyzed by gas chromatography-mass spectroscopy 3 and 6 h after exposure to the test pollutants to determine removal efficiency by monitoring the decline in concentration over 6 h within sealed glass containers. To determine removal by the plant, removal by other means (glass, plant pot, media) was subtracted. The removal efficiency, expressed on a leaf area basis for each volatile organic compound (VOC), varied with plant

species. Of the 28 species tested, Hemigraphis alternata, Hedera helix, Hoya carnosa, and Asparagus densiflorus had the highest removal efficiencies for all pollutants; Tradescantia pallida displayed superior removal efficiency for four of the five VOCs (i.e., benzene, toluene, TCE, and{alpha} -pinene). The five species ranged in their removal efficiency from 26.08 to 44.04 {micro}g{middle dot}m-3{middle dot}m-2{middle dot}h-1 of the total VOCs. Fittonia argyroneura effectively removed benzene, toluene, and TCE. Ficus benjamina effectively removed octane and{alpha} -pinene, whereas Polyscias fruticosa effectively removed octane. The variation in removal efficiency among species indicates that for maximum improvement of indoor air quality, multiple species are needed. The number and type of plants should be tailored to the type of VOCs present and their rates of emanation at each specific indoor location.

Tait, R. J., et al. (2009). "An electronic tree inventory for arboriculture management." Knowledge-Based Systems 22(7): 552-556.

The integration of Global Positioning System (GPS) technology into mobile devices provides them with an awareness of their physical location. This geospatial context can be employed in a wide range of applications including locating nearby places of interest as well as guiding emergency services to incidents. In this research, a GPS-enabled Personal Digital Assistant (PDA) is used to create a computerised tree inventory for the management of arboriculture. Using the General Packet Radio Service (GPRS), GPS information and arboreal image data are sent to a web-server. An office-based PC running customised Geographical Information Software (GIS) then automatically retrieves the GPS tagged image data for display and analysis purposes. The resulting application allows an expert user to view the condition of individual trees in greater detail than is possible using remotely sensed imagery.

Sagoff, M. (2009). "The Economic Value of Ecosystem Services." Bioscience 59(6): 461-461.

Patterson, T. M. and D. L. Coelho (2009). "Ecosystem services: Foundations, opportunities, and challenges for the forest products sector." Forest Ecology and Management 257(8): 1637-1646.

The ecosystem service concept has been proposed as a meaningful framework for natural resource management. In theory it holds concomitant benefit and consequence for the forest product sector. However, numerous barriers impede practitioners from developing concrete and enduring responses to emerging ecosystem service markets, policies, and initiatives. Principle among these barriers is that the ecosystem service concept has a complex history, numerous definitions in use, and an astounding diversity in rationale and application. This article provides a conceptual review of ecosystem services and its economic foundations, distinguishes among several current definitions of the term and their relatedness to strategies in practical application, discusses diverse approaches to valuation, and explores potential for future relevance in forest product and other sectors. Published by Elsevier B.V.

Paoletti, E. (2009). "Ozone and urban forests in Italy." Environmental Pollution 157(5): 1506-1512.

Ozone levels along urban-to-rural gradients in three Italian cities (Milan, Florence, Bari) showed that average AOT40 values at rural and suburban sites were 2.6 times higher than those determined at urban sites. However, O-3 also exceeded the European criteria to protect forest health at urban sites, even when the standards

for human health protection were met. For protecting street trees in Mediterranean cities, the objectives of measurement at urban sites should extend from the protection of human health to the protection of vegetation as well. A review of forest effects on O-3 pollution and of O-3 pollution on forest conditions in Italian cities showed that it was not possible to distinguish the effect of O-3 in the complex mixture of urban pollutants and stressors. A preliminary list of tree species for urban planning in the Mediterranean area shows the average tree capacity of O-3 removal and VOC emission.

Getter, K. L., et al. (2009). "Carbon Sequestration Potential of Extensive Green Roofs." Environmental Science & Technology 43(19): 7564-7570.

Two studies were conducted with the objective of quantifying the carbon storage potential of extensive green roofs. The first was performed on eight roofs in Michigan and four roofs in Maryland, ranging from 1 to 6 years in age. All 12 green roofs were composed primarily of Sedum species, and substrate depths ranged from 2.5 to 12.7 cm. Above ground plant material was harvested in the fall of 2006. On average, these roofs stored 162 g C·m−2 in aboveground biomass. The second study was conducted on a roof in East Lansing, MI. Twenty plots were established on 21 April 2007 with a substrate depth of 6.0 cm. In addition to a substrate only control, the other plots were sown with a single species of Sedum (S. acre, S. album, S. kamtshaticum, or S. spurium). Species and substrate depth represent typical extensive green roofs in the United States. Plant material and substrate were harvested seven times across two growing seasons. Results at the end of the second year showed that aboveground plant material storage varied by species, ranging from 64 g C·m−2 (S. acre) to 239 g C·m−2 (S. album), with an average of 168 g C·m−2. Belowground biomass ranged from 37 g C·m−2 (S. acre) to 185 g C·m−2 (S. kamtschaticum) and averaged 107 g C·m−2. Substrate carbon content averaged 913 g C·m−2, with no species effect, which represents a sequestration rate of 100 g C·m−2 over the 2 years of this study. The entire extensive green roof system sequestered 375 g C·m−2 in above- and belowground biomass and substrate organic matter.

Dwivedi, P., et al. (2009). "Ecological benefits of urban forestry: The case of Kerwa Forest Area (KFA), Bhopal, India." Applied Geography 29(2): 194-200.

In developing countries like India, migration of people from rural to urban areas is responsible for ever expanding urban boundaries. This trend is exerting significant pressure on unprotected natural forests located near urban centers. This paper highlights the case of Kerwa Forest Area (KFA), located at about 10 km from the city of Bhopal, capital of Madhya Pradesh state. The objectives of this study are to quantify the extent of disturbance faced and ecosystem services provided by the KFA. Suitable spatial technologies and forest sampling techniques have been used to achieve the objectives of the study. It was found that the KFA is currently facing severe anthropogenic pressure. Parts of the KFA, located close to the settlements, were found more disturbed than the parts which were located far from the settlements. In spite of disturbances, KFA is a habitat for many threatened and endangered plant, animal, and bird species. KFA also plays a critical role of a carbon sink with a total storage of about 19.5 thousand tons of aboveground carbon. Immediate precautionary measures are required to prevent further degradation of the KFA for ensuring better environmental quality for the residents of Bhopal city in the future.

Burghardt, K. T., et al. (2009). "Impact of Native Plants on Bird and Butterfly Biodiversity in Suburban Landscapes." Conservation Biology 23(1): 219-224.

Managed landscapes in which non-native ornamental plants are favored over native vegetation now dominate the United States, particularly east of the Mississippi River. We measured how landscaping with native plants affects the avian and lepidopteran communities on 6 pairs of suburban properties in southeastern Pennsylvania. One property in each pair was landscaped entirely with native plants and the other exhibited a more conventional suburban mixture of plants 2014 a native canopy with non-native groundcover and shrubs. Vegetation sampling confirmed that total plant cover and plant diversity did not differ between treatments, but non-native plant cover was greater on the conventional sites and native plant cover was greater on the native sites. Several avian (abundance, species richness, biomass, and breeding-bird abundance) and larval lepidopteran (abundance and species richness) community parameters were measured from June 2006 to August 2006. Native properties supported significantly more caterpillars and caterpillar species and significantly greater bird abundance, diversity, species richness, biomass, and breeding pairs of native species. Of particular importance is that bird species of regional conservation concern were 8 times more abundant and significantly more diverse on native properties. In our study area, native landscaping positively influenced the avian and lepidopteran carrying capacity of suburbia and provided a mechanism for reducing biodiversity losses in human-dominated landscapes.

Sagoff, M. (2008). "On the economic value of ecosystem services." Environmental Values 17(2): 239-257.

The productive services of nature, such as the ability of fertile soil to grow crops, receive low market prices not because markets fail but because many natural resources, such as good cropland, are abundant relative to effective demand. Even when one pays nothing for a service such as that the wind provides in pollinating crops, this is its 'correct' market price if the supply is adequate and free. The paper argues that ecological services are either too 'lumpy' to price in incremental units (for example, climatic systems), priced competitively, or too cheap to meter. The paper considers counter-examples and objections.

Jim, C. Y. and W. Y. Chen (2008). "Assessing the ecosystem service of air pollutant removal by urban trees in Guangzhou (China)." Journal of Environmental Management 88(4): 665-676.

In Chinese cities, air pollution has become a serious and aggravating environmental problem undermining the sustainability of urban ecosystems and the quality of urban life. Besides technical solutions to abate air pollution, urban vegetation is increasingly recognized as an alternative ameliorative method by removing some pollutants mainly through dry deposition process. This paper assesses the capability and monetary value of this ecosystem service in Guangzhou city in South China. The results indicated an annual removal of SO2, NO2 and total suspended particulates at about 312.03Mg, and the benefits were valued at RMB90.19 thousand (US$1.00 = RMB8.26). More removal was realized by recreational land use due to a higher tree cover. Higher concentration of pollutants in the dry winter months induced more removal. The lower cost of pollution abatement in China generated a relatively subdued monetary value of this environmental benefit in comparison with developed countries. Younger districts with more extensive urban trees stripped more pollutants from the air, and this capacity was anticipated to increase further as their trees gradually reach final dimensions and establish a greater tree cover. Tree cover and pollutant concentration constitute the main factors in pollutant removal by urban trees. The efficiency of atmospheric cleansing by trees in congested Chinese cities could be improved by planting more trees other than shrubs or grass, diversifying species composition and biomass structure, and providing sound green space management. The implications for greenery design were discussed with a view to maximizing this ecosystem service in Chinese cities and other developing metropolises.

Heidt, V. and M. Neef (2008). Benefits of Urban Green Space for Improving Urban Climate. Ecology, Planning, and Management of Urban Forests: 84-96.

Urban settlements transform the natural environment so greatly that people tend to see the city only as an employment site, and economic and cultural center. Thus a growing number of people prefer to reside in greener suburbs or rural areas. This results in increased automobile commuter traffic, accompanied by traffic jams, accidents, stress, and ever more damage to the environment. Concepts of sustainable development or the ecological city represent strategies for changing these negative trends. The purpose for doing so is principally the well-being of a city's residents. Often this entails bringing more of the natural environment back into the city, because urban green space fulfills several critical functions in an urban context that benefit people's quality of life. There is a broad consensus about the importance, and therefore the value, of urban green space in cities as currently constructed, in addition to its value in planning ecological cities. Steadily growing traffic and urban heat not only damage the environment, but also incur social and economic costs. As we explain further, we can save costs even by making small changes to existing situations. Furthermore, we maintain and show that an integrated approach is needed for designing and maintaining urban green space. The main thesis of this chapter, therefore, is as follows: To provide sufficient quality of life in high-density cities, it is important to maintain and restore an urban green space system; moreover, urban green space and a comfortable urban climate also produce social and economic benefits.

Xiao, Q., et al. (2007). "Hydrologic processes at the urban residential scale." Hydrological Processes 21(16): 2174-2188.

In the face of increasing urbanization, there is growing interest in application of microscale hydrologic solutions to minimize storm runoff and conserve water at the source. In this study, a physically based numerical model was developed to understand hydrologic processes better at the urban residential scale and the interaction of these processes among different best management practices (BMPs). This model simulates hydrologic processes using an hourly interval for over a full year or for specific storm events. The model was applied to treatment and control single-family residential parcels in Los Angeles, California. Data collected from the control and treatment sites over 2 years were used to calibrate and validate the model. Annual storm runoff to the street was eliminated by 97% with installation of rain gutters, a driveway interceptor, and lawn retention basin. Evaluated individually, the driveway interceptor was the most effective BMP for storm runoff reduction (65%), followed by the rain gutter installation (28%), and lawn converted to retention basin (12%). An 11 m(3) cistern did not substantially reduce runoff, but provided 9% of annual landscape irrigation demand. Simulated landscape irrigation water use was reduced 53% by increasing irrigation system efficiency, and adjusting application rates monthly based on plant water demand. The model showed that infiltration and surface runoff processes were particularly sensitive to the soil's physical properties and its effective depth. Replacing the existing loam soil with clay soil increased annual runoff discharge to the street by 63% when climate and landscape features remained unchanged. Copyright (c) 2006 John Wiley & Sons, Ltd.

Oberndorfer, E., et al. (2007). "Green roofs as urban ecosystems: Ecological structures, functions, and services." Bioscience 57: 823-833.

Green roofs (roofs with a vegetated surface and substrate) provide ecosystem services in urban areas, including improved storm-water management, better regulation of building temperatures, reduced urban heat-island effects, and increased urban wildlife habitat. This article reviews the evidence for these benefits and examines the biotic and abiotic components that contribute to overall ecosystem services. We emphasize the potential for improving green-roof function by understanding the interactions between its ecosystem elements, especially the relationships among growing media, soil biota, and vegetation, and the interactions between community structure and ecosystem functioning. Further research into green-roof technology should assess the

efficacy of green roofs compared to other technologies with similar ends, and ultimately focus on estimates of aggregate benefits at landscape scales and on more holistic cost-benefit analyses.

MacDonald, J. A. (2007) How cities use parks for climate change management.

The urban heat island effect, and its mostly negative consequences of modified temperature, wind, precipitation, and air quality patterns, is the primary instigator of local climate change. Continued urbanization of the global population will only hasten further change.The increasing impact of urban heat islands on local climates may eventually translate to more widespread climate change, possibly global, if left unchecked. Parks are the first and best line of defense against these changes. Urban parks cool and clean the air, improve and modify local wind circulations, and better regulate precipitation patterns.Well-vegetated parks, in a variety of forms and sizes, mitigate the impact of the urban heat island and minimize local climate change. Reduced impact of the urban heat island may prolong or even prevent more widespread global climate change as cities continue to increase in both size and number.

Brethour, C., et al. (2007). Literature review of documented health and environmental benefits derived from ornamental horticulture products, Agriculture and Agri-Food Canada Markets and Trade, Ottawa, ON.

A review of the literature demonstrated that ornamental horticulture has a wider suite of benefits than expected. Plants can provide multiple benefits in terms of the economy, environment and human lifestyles. Many of these benefits, however, are not well known or understood within the general population. As a result, there is a considerable opportunity for the ornamental horticulture industry to sell more products based on the benefits identified throughout this literature review.

Wolf, K. L. (2006). "Assessing public response to freeway roadsides - Urban forestry and context-sensitive solutions." Highway Facility Design 2006(1984): 102-111 167.

Social science methods can be used to assess how the public values context-sensitive solutions. The roadside landscape is a public lands resource that has many functions and provides many benefits. Diverse stakeholders may have varied expectations for roadside design. The urban forest is often a contested component of the urban roadside. Two research surveys based on landscape assessment literature were used to assess and quantify public preferences and perceptions with regard to trees in highspeed and freeway roadsides. One photo questionnaire was distributed in urban areas nationally and the other in Washington State. To elicit public attitudes about visual quality and community image, each survey included design visualizations constructed with digitally edited photographs. Research results were consistent across both studies. Respondents judged images with increasing amounts of roadside vegetation, including trees, to have a higher amenity value. The presence of more extensive community greening was associated with positive consumer inferences and greater willingness to pay for goods and services. There was little variation in responses across respondent demographics. Results provide an empirical basis for flexible highway design and promote planning options for roadside urban forests that address multiple stakeholder interests.

Pataki, D. E., et al. (2006). "Urban ecosystems and the North American carbon cycle." Global Change Biology 12(11): 2092-2102.

Approximately 75-80% of the population of North America currently lives in urban areas as defined by national census bureaus, and urbanization is continuing to increase. Future trajectories of fossil fuel emissions are associated with a high degree of uncertainty; however, if the activities of urban residents and the rate of urban land conversion can be captured in urban systems models, plausible emissions scenarios from major cities may be

generated. Integrated land use and transportation models that simulate energy use and traffic-related emissions are already in place in many North American cities. To these can be added a growing dataset of carbon gains and losses in vegetation and soils following urbanization, and a number of methods of validating urban carbon balance modeling, including top down atmospheric monitoring and urban 'metabolic' studies of whole ecosystem mass and energy flow. Here, we review the state of our understanding of urban areas as whole ecosystems with regard to carbon balance, including both drivers of fossil fuel emissions and carbon cycling in urban plants and soils. Interdisciplinary, whole-ecosystem studies of the socioeconomic and biophysical factors that influence urban carbon cycles in a range of cities may greatly contribute to improving scenarios of future carbon balance at both continental and global scales.

McPherson, E. G. and J. Muchnick (2005). "Effects of Street Tree Shade on Asphalt Concrete Pavement Performance." Journal of Arboriculture 31(6): 303-310.

Forty-eight street segments were paired into 24 highand low-shade pairs in Modesto, California, U.S. Field data were collected to calculate a Pavement Condition Index (PCI) and Tree Shade Index (TSI) for each segment. Statistical analyses found that greater PCI was associated with greater TSI, indicating that tree shade was partially responsible for reduced pavement fatigue cracking, rutting, shoving, and other distress. Using observed relations between PCI and TSI, an unshaded street segment required 6 slurry seals over 30 years, while an identical one planted with 12 crape myrtles (Lagerstroemia indica, 4.4 m [14 ft] crown diameter) required 5 slurry seals, and one with 6 Chinese hackberry (Celtis sinensis, 13.7 m [45 ft] crown diameter) required 2.5 slurry seals. Shade from the large hackberries was projected to save $7.13/m2 ($0.66/ft2) over the 30-year period compared to the unshaded street.

Nali, C., et al. (2004). "Plants as indicators of urban air pollution (ozone and trace elements) in Pisa, Italy." Journal of Environmental Monitoring 6(7): 636-645.

A biennial integrated survey, based on the use of vascular plants for the bioindication of the effects of tropospheric ozone, was performed in the area of Pisa (Tuscany, Central Italy). It also investigated the distribution of selected trace elements in plants and the data were compared with those obtained from the use of passive samplers, automatic analysers of ozone and lichen biodiversity. Photochemically produced ozone proved to be present during the warm season, with maximum hourly means surpassing 100 ppb: the use of supersensitive tobacco Bel-W3 confirmed the value of detailed, cost-effective, monitoring surveys. Trials with clover clones demonstrate that sensitive plants undergo severe biomass reduction in the current ozone regime. The mean NC-S (clover clone sensitive to ozone): NC-R (resistant) biomass ratio ranged from 0.7 (in 1999) to 0.5 (in 2000). The economic impact of these reductions deserves attention. The data obtained using passive ozone samplers exceeded those obtained using an automatic analyser. The mapping of epiphytic lichen biodiversity was not related to the geographical ozone distribution as can be seen from the tobacco's response. Lettuce plants grown under standardized conditions were used positively as bioaccumulators of trace elements: Pb was abundantly recovered, but a large portion of this element was removed by washing.

Haberl, H., et al. (2004). "Land use and sustainability indicators. An introduction." Land Use Policy 21(3): 193-198.

Bioproductive land is one of the most significant natural resources. People use the land for receiving ecological services. This leads to humans using and favouring certain species, while competing with all other species. Land use can create diverse cultural landscapes of outstanding aesthetic, economic and ecological value,

but it may equally result in land degradation, soil loss and impoverished ecosystems. Hence land use is shaped by processes of society-nature interaction. These processes can detract from sustainability--in other words, society-nature interaction may deplete the natural capital upon which the provision of ecosystem services for humans depends. Sustainability indicators aim at monitoring key aspects of society-nature interaction in order to generate information needed to document the current state and the history leading up to it. Moreover, they are useful to communicate complex sustainability problems within the scientific community, to policy-makers and the broad public. This paper introduces a special issue that seeks to contribute to the development of sustainability indicators that track society-nature interaction. We focus on a variety of concepts that measure socio-economic metabolism. All the discussed approaches relate socio-economic energy and material flows to the bioproductive area needed to support them, above all, the ecological footprint and the human appropriation of net primary production. In addition, this special issue also analyses the consequences of land use intensity on the diversity, naturalness and patterns of landscapes.

Chiesura, A. (2004). "The role of urban parks for the sustainable city." Landscape and Urban Planning 68(1): 129-138.

International efforts to preserve the natural environment are mainly concerned with large, bio-diverse and relatively untouched ecosystems or with individual animal or vegetal species, either endangered or threatened with extinction. Much less attention is being paid to that type of nature close to where people live and work, to small-scale green areas in cities and to their benefits to people. Increasing empirical evidence, however, indicates that the presence of natural areas contributes to the quality of life in many ways. Besides many environmental and ecological services, urban nature provides important social and psychological benefits to human societies, which enrich human life with meanings and emotions. The main concern of this paper is to address the importance of urban nature for citizens' well being and for the sustainability of the city they inhabit. Some results of a survey conducted among visitors of an urban park in Amsterdam (The Netherlands) are presented and discussed. The issues investigated concern people's motives for urban nature, the emotional dimension involved in the experience of nature and its importance for people's general well being. Results confirm that the experience of nature in urban environment is source of positive feelings and beneficial services, which fulfill important immaterial and non-consumptive human needs. Implications for the sustainability of the city will be analyzed and discussed.

Chee, Y. E. (2004). "An ecological perspective on the valuation of ecosystem services." Biological Conservation 120(4): 549-565.

Ecosystem services are the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfill human life. Ecosystem service valuation is being developed as a vehicle to integrate ecological understanding and economic considerations to redress the traditional neglect of ecosystem services in policy decisions. This paper presents a critical review on the neoclassical economic framework, tools used for economic valuation of ecosystem services and the economic welfare approach to collective decision-making, from an ecological perspective. The applicability of the framework and techniques for valuing ecosystem services are evaluated in light of the challenges posed by the complex, non-linear nature of many ecosystem services. Decisions concerning ecosystem management are often complex, socially contentious and fraught with uncertainty. Although judicious application of economic valuation techniques to ecosystem services can provide valuable information for conceptualizing decision choices and evaluating management options, there are serious limitations in the economic welfare approach to decision-making. These shortcomings and their implications for ecosystem management are elucidated and alternative approaches that emphasize participation, explicit treatment of uncertainty and transparent decision-making processes are discussed.

Pauleit, S. (2003). "Urban street tree plantings: indentifying the key requirements." Proceedings of the Institution of Civil Engineers-Municipal Engineer 156(1): 43-50.

Trees fulfill important aesthetic, social and environmental functions in urban areas. However, tree life is increasingly under stress, leading to poor vitality and tree decline, particularly in urban streets. The requirements for healthy tree life are broadly known. Criteria for the design of planting sites in streets, choice of tree species and maintenance requirements are outlined in the paper. However, a European survey reveals the wide variance of tree planting and management practice. UK cities and towns performed poorly against criteria such as level of expenditure for trees, street tree quality and site preparation. Evidently, trees are very much undervalued and only an afterthought in the process of planning, design and management of streets. There is an urgent need to develop and apply comprehensive concepts for sustainable urban forests and specifically for street tree plantings. Standards for site planning, as well as increased knowledge of suitable tree species and tree quality standards are key to achieving this goal. Information on best practice needs to be more widely disseminated. The European pilot survey was a first step towards establishing an information network across Europe to collect the information needed for this purpose. There is a need for close collaboration between civil engineers and landscape architects from a very early stage to integrate tree plantings into the design of streets, in order to maximise their benefits and avoid potential conflicts with traffic and utilities.

Benedict, M. and E. T. McMahon (2003, 08/06/2010). "How cities use parks for green infrastructure." from http://www.planning.org/cityparks/briefingpapers/index.htm.

Just as growing communities need to upgrade and expand their built infrastructure of roads, sewers, and utilities, they also need to upgrade and expand their green infrastructure, the interconnected system of green spaces that conserves natural ecosystem values and functions, sustains clear air and water, and provides a wide array of benefits to people and wildlife. Green infrastructure is a community's natural life support system, the ecological framework needed for environmental and economic sustainability. In their role as green infrastructure, parks and open space are a community necessity. By planning and managing urban parks as parts of an interconnected green space system, cities can reduce flood control and stormwater management costs. Parks can also protect biological diversity and preserve essential ecological functions while serving as a place for recreation and civic engagement. They can even help shape urban form and reduce opposition to development, especially when planned in concert with other open spaces.

Shashua-Bar, L. and M. E. Hoffman (2002). "The Green CTTC model for predicting the air temperature in small urban wooded sites." Building and Environment 37(12): 1279-1288.

An analytical model, the Green CTTC (cluster thermal time constant) model, for predicting diurnal air temperature inside an urban wooded site, is the object of this study. The proposed model is based on the same principles as the CTTC model, developed earlier by M.E. Hoffman and colleagues, with the addition of vegetation effects. It is shown that the tree thermal effect can be evaluated either as the shade effect partly offset by the convection component of the tree radiation balance or, equivalently, as the combined effect of evapotranspiration and the change in the plant heat storage. In this paper, the former approach is adopted. Simulations for testing the validity of the Green CTTC model were carried out on summer data of 11 small urban wooded sites in the Tel-Aviv metropolitan area near the Mediterranean sea coast. Results show a satisfactory fit, with average root-mean-square-error < 0.5 K for all studied sites and time intervals at 09:00, 15:00, and 18:00 h (summer time). The CTTC values and the convection parameters were estimated from the empirical data, using a novel procedure. The proposed model, which can be enlarged to encompass the cases of groves and lawns, is an appropriate tool for

assessment of the climatic impact of trees and other greeneries on urban design alternatives. (C) 2002 Elsevier Science Ltd. All rights reserved.

Nowak, D. J. and D. E. Crane (2002). "Carbon storage and sequestration by urban trees in the USA." Environmental Pollution 116(3): 381-389.

Based on field data from 10 USA cities and national urban tree cover data, it is estimated that urban trees in the coterminous USA currently store 700 million tons of carbon ($14,300 million value) with a gross carbon sequestration rate of 22.8 million tC/yr ($460 million/year). Carbon storage within cities ranges from 1.2 million tC in New York, NY, to 19,300 tC in Jersey City, NJ. Regions with the greatest proportion of urban land are the Northeast (8.5%) and the southeast (7.1%). Urban forests in the north central, northeast, south central and southeast regions of the USA store and sequester the most carbon, with average carbon storage per hectare greatest in southeast, north central, northeast and Pacific northwest regions, respectively. The national average urban forest carbon storage density is 25.1 tC/ha, compared with 53.5 tC/ha in forest stands. These data can be used to help assess the actual and potential role of urban forests in reducing atmospheric carbon dioxide, a dominant greenhouse gas. Published by Elsevier Science Ltd.

Brack, C. L. (2002). "Pollution mitigation and carbon sequestration by an urban forest." Environmental Pollution 116: S195-S200.

At the beginning of the 1900s, the Canberra plain was largely treeless. Graziers had carried out extensive clearing of the original trees since the 1820s leaving only scattered remnants and some plantings near homesteads. With the selection of Canberra as the site for the new capital of Australia, extensive tree plantings began in 1911. These trees have delivered a number of benefits, including aesthetic values and the amelioration of climatic extremes. Recently, however, it was considered that the benefits might extend to pollution mitigation and the sequestration of carbon. This paper outlines a case study of the value of the Canberra urban forest with particular reference to pollution mitigation. This study uses a tree inventory, modelling and decision support system developed to collect and use data about trees for tree asset management. The decision support system (DISMUT) was developed to assist in the management of about 400,000 trees planted in Canberra. The size of trees during the 5-year Kyoto Commitment Period was estimated using DISMUT and multiplied by estimates of value per square meter of canopy derived from available literature. The planted trees are estimated to have a combined energy reduction, pollution mitigation and carbon sequestration value of US$20-67 million during the period 2008-2012. (C) 2001 Elsevier Science Ltd. All rights reserved.

Sorace, A. (2001). "Value to wildlife of urban-agricultural parks: A case study from Rome urban area." Environmental Management 28(4): 547-560.

Urban-agricultural parks could have some advantages to wildlife because of less intensive agricultural procedures, absence of hunting pressure, and reduced human disturbance. In this study, the breeding and wintering bird communities and the small mammal community in an urban-agricultural park of Rome were compared to those of a close urban park and a close agricultural, area just outside the city, The aim was to assess the best destination and management of wildlife in natural areas at the urban-rural interface, Richness and diversity of bird communities were higher in the urban-agricultural park. Due to habitat features and probably human disturbances, but not to urbanization, predation, and competition factors, the urban park drastically reduces the abundance of decreasing open-land bird species. Abundance of these species was not significantly different in the urban-agricultural park and in the agricultural area. In the urban-agricultural and urban park, bird and mammal pest species were more abundant than they were in the agricultural area. Regarding decreasing abundance of small mammal species, no significant difference among the study areas was observed. Urban-

agricultural park is a better choice than urban park for wildlife. Thus, a higher number of preserved urban natural areas should be devoted to urban-agricultural parks. However, to increase the abundance of open-land species and in general wildlife, a less intensive management of cultivated and pasture patches is necessary.

Jo, H. K. and E. G. McPherson (2001). "Indirect carbon reduction by residential vegetation and planting strategies in Chicago, USA." Journal of Environmental Management 61(2): 165-177.

Concern about climate change has evoked interest in the potential for urban vegetation to help reduce the levels of atmospheric carbon. This study applied computer simulations to try to quantify the modifying effects of existing vegetation on the indirect reduction of atmospheric carbon for two residential neighborhoods in north-west Chicago. The effects of shading, evapotranspiration, and windspeed reduction were considered and were found to have decreased carbon emissions by 3.2 to 3.9% per year for building types in study block I where tree cover was 33%, and -0.2 to 3.8% in block 2 where free cover was 11%. This resulted in a total annual reduction of carbon emission averaging 158.7 (+/-12.8) kg per residence in block I and 18.1 (+/-5.4) kg per residence in block 2. Windspeed reduction greatly contributed to the decrease of carbon emission. However, shading increased annual carbon emission from the combined change in heating and cooling energy use due to many frees in the wrong locations, which increase heating energy use during the winter The increase of carbon emission from shading is somewhat specific to Chicago, due in part to the large amount of clean, nuclear-generated cooling energy and the long heating season. In Chicago, heating energy is required for about eight months from October to May and cooling energy is used for the remaining 4 months from June to September If fossil fuels had been the primary source for cooling energy and the heating season had been shorter, the shading effects on the reduction of carbon emission would be greater. Planting of large frees close to the west wall of buildings, dense planting on the north, and avoidance of planting on the south are recommended to maximize indirect carbon reduction by residential vegetation, in Chicago and other mid and high-latitude cities with long heating seasons. (C) 2001 Academic Press.

Pauleit, S. and F. Duhme (2000). "Assessing the environmental performance of land cover types for urban planning." Landscape and Urban Planning 52(1): 1-20.

Urban planning and decision-making for sustainable development urgently need data of high spatial resolution to establish the relationship between the socio-economic performance of the urban system and its different sub-units (i.e. housing schemes, commercial and industrial developments, services) on the one hand and their environmental impacts of these subunits on the other. To achieve this task, a system was developed to delineate urban land cover units. The approach was tested for the city of Munich. The units delineate the fine-grained pattern of urban built-up and open spaces. The typology was based on established categories of zoning and development plans. In addition, the units were delineated on an aggregated scale to generate a synoptic understanding of the urban "metabolism" for different "strategic" levels of urban planning. A case study on urban hydrology is presented to characterize aspects of the metabolism of the urban system. Additional case studies covered urban climates, energy demand for space heating and carbon dioxide emissions. Results showed that the cover units and types had distinct environmental features. Furthermore the causal links with urban physical and land use features were investigated. Based on the hydrological case study, environmental targets and standards to promote sustainable development are proposed. (C) 2000 Elsevier Science B.V. All rights reserved.

Newell, R. G. and R. N. Stavins (2000). "Climate change and forest sinks: Factors affecting the costs of carbon sequestration." Journal of Environmental Economics and Management 40(3): 211-235.

The possibility of encouraging the growth of forests as a means of sequestering carbon dioxide has received considerable attention, partly because of evidence that this can be a relatively inexpensive means of combating climate change. But how sensitive are such estimates to specific conditions? We examine the sensitivity

of carbon sequestration costs to changes in critical factors, including the nature of management and deforestation regimes, silvicultural species, relative prices, and discount rates. (C) 2000 Academic Press.

Kuttler, W. and A. Strassburger (1999). "Air quality measurements in urban green areas - a case study." Atmospheric Environment 33(24-25): 4101-4108.

The influence of traffic-induced pollutants (e.g. CO, NO, NO2 and O-3) on the air quality of urban areas was investigated in the city of Essen, North Rhine-Westphalia (NRW), Germany. Twelve air hygiene profile measuring trips were made to analyse the trace gas distribution in the urban area with high spatial resolution and to compare the air hygiene situation of urban green areas with the overall situation of urban pollution. Seventeen measurements were made to determine the diurnal concentration courses within urban parks (summer conditions: 13 measurements, 530 30 min mean values, winter conditions: 4 measurements, 128 30 min mean values). The measurements were carried out during mainly calm wind and cloudless conditions between February 1995 and March 1996. It was possible to establish highly differentiated spatial concentration patterns within the urban area. These patterns were correlated with five general types of land use (motorway, main road, secondary road, residential area, green area) which were influenced to varying degrees by traffic emissions. Urban parks downwind from the main emission sources show the following typical temporal concentration courses: In summer rush-hour-dependent CO, NO and NO2 maxima only occurred in the morning. A high NO2/NO ratio was established during weather conditions with high global radiation intensities (K > 800 W m(-2)), which may result in a high O-3 formation potential. Some of the values measured found in one of the parks investigated (Gruga Park, Essen, area: 0.7 km(2)), which were as high as 275 mu g m(-3) O-3 (30-min mean value) were significantly higher than the German air quality standard of 120 mu g m(-3) (30-min mean value, VDI Guideline 2310, 1996) which currently applies in Germany and about 20% above the maximum values measured on the same day by the network of the North Rhine-Westphalian State Environment Agency. In winter high CO and NO concentrations occur in the morning and during the afternoon rush-hour. The highest concentrations (CO = 4.3 mg m(-3), NO = 368 mu g m(-3), 30-min mean values) coincide with the increase in the evening inversion. The maximum measured values for CO, NO and NO2 do not, however, exceed the German air quality standards in winter and summer. (C) 1999 Elsevier Science Ltd. All rights reserved.

Bolund, P. and S. Hunhammar (1999). "Ecosystem services in urban areas." Ecological Economics 29(2): 293-301.

Humanity is increasingly urban, but continues to depend on Nature for its survival. Cities are dependent on the ecosystems beyond the city limits, but also benefit from internal urban ecosystems. The aim of this paper is to analyze the ecosystem services generated by ecosystems within the urban area. 'Ecosystem services' refers to the benefits human populations derive from ecosystems. Seven different urban ecosystems have been identified: street trees; lawns/parks; urban forests; cultivated land wetlands; lakes/sea; and streams. These systems generate a range of ecosystem services. In this paper, six local and direct services relevant for Stockholm are addressed: air filtration, micro climate regulation, noise reduction, rainwater drainage, sewage treatment, and recreational and cultural values. It is concluded that the locally generated ecosystem services have a substantial impact on the quality-of-life in urban areas and should be addressed in land-use planning. (C) 1999 Elsevier Science B.V. All rights reserved.

Wagner, J. E., et al. (1998). "A role for economic analysis in the ecosystem management debate." Landscape and Urban Planning 40(1-3): 151-157.

Ecosystem management's underpinnings have been biological in nature-the concern for ecosystem integrity, health, and resilience. This intent has been translated into a similar societal goal. However, its philosophy is still evolving biologically and socially. Since the geographic boundaries of an ecosystem may probably cross many

different ownership types, this leaves landowners wondering how this new management approach will affect them. We discuss the role of economics within the ecosystem management debate. In addition, we also examine three existing economic analytical techniques that can be used to analyze ecosystem management, discuss the contributions of these techniques and their limitations, and identify three key points that an economic analysis should address. Finally, we survey five examples of ecosystem management in practice on United States Department of Agriculture Forest Service lands. (C) 1998 Elsevier Science B.V.

McPherson, E. G., et al. (1998). "Estimating cost effectiveness of residential yard trees for improving air quality in Sacramento, California, using existing models." Atmospheric Environment 32(1): 75-84.

The Sacramento Municipal Utility District's (SMUD) shade tree program will result in the planting of 500,000 trees and has been found to produce net benefits from air conditioning savings. In this study we assume three scenarios (base, highest, and lowest benefits) based on the SMUD program and apply Best Available Control Technology (BACT) cost analysis to determine if shade trees planted in residential yards can be a cost effective means to improve air quality. Planting and maintenance costs, pollutant deposition, and biogenic hydrocarbon emissions are estimated annually for 30 years with existing deterministic models. For the base case, the average annual dollar benefit of pollutant uptake was $895 and the cost of biogenic hydrocarbon emissions was $512, for a net pollutant uptake benefit of $383 per 100 trees planted. The uniform annual payment necessary to repay planting and maintenance costs with a 10% rate of interest was $749. When high biogenic hydrocarbon emitting tree species were replaced with low-emitters, the base case benefit-cost ratio (BCR) increased from 0.5:1 to 0.9:1. The BCR for the ''highest'' and ''lowest'' benefit cases were 2.2:1 and -0.8:1, respectively. Although SMUD plantings produce cost effective energy savings, our application of the BACT analysis does not suggest convincing evidence that there is cost savings when only air quality benefits are considered. Published by Elsevier Science Ltd.

McPherson, E. G., et al. (1998). "Estimating cost effectiveness of residential yard trees for improving air quality in Sacramento, California, using existing models - Reply." Atmospheric Environment 32(14-15): 2710-2711.

Costanza, R., et al. (1998). "The value of the world's ecosystem services and natural capital." Ecological Economics 25(1): 3-15.

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16-54 trillion (1012) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

vanWilgen, B. W., et al. (1996). "Valuation of ecosystem services." Bioscience 46(3): 184-189.

Presents a case study from the South African fynbos ecosystems, stating that watershed ecosystems provide quantifiable benefits that can justify management expenditure. Information regarding the invasion of alien plants and their affect on water sources in the mountain catchment areas of the Western Cape Province, South Africa; Economics of water and catchment management.

Nowak, D. J., et al. (1996). "Measuring and analyzing urban tree cover." Landscape and Urban Planning 36(1): 49-57.

Measurement of city tree cover can aid in urban vegetation planning, management, and research by revealing characteristics of vegetation across a city. Urban tree cover in the United States ranges from 0.4% in Lancaster, California, to 55% in Baton Rouge, Louisiana. Two important factors that affect the amount of urban tree cover are the natural environment and land use. Urban tree cover is highest in cities that developed in naturally forested areas (31%), followed by grassland cities (19%) and desert cities (10%), but showed wide variation based on individual city characteristics. Tree cover ranged from 15 to 55% for cities in forested areas, 5 to 39% for those in grassland areas, and 0.4 to 26% for cities developed in desert regions, Park and residential lands along with vacant lands in forested areas generally have the highest tree cover among different land uses. Methods of measuring urban tree cover are presented as are planning and management implications of tree-cover data.

McPherson, E. G., et al. (1996). "''Bact'' analysis: Are there cost effective air quality benefits from trees?" Ninth Joint Conference on Applications of Air Pollution Meteorology with a&Wma: 355-359.

Mcpherson, E. G. (1994). "Using Urban Forests for Energy Efficiency and Carbon Storage." Journal of Forestry 92(10): 36-&.

Levitt, D. G., et al. (1994). "Neighborhood-Scale Temperature Variation Related to Canopy Cover Differences in Southern California." 21st Conference on Agricultural and Forest Meteorology/11th Conference on Biometeorology and Aerobiology: 349-352 528.

Mcpherson, E. G. (1993). "Monitoring Urban Forest Health." Environmental Monitoring and Assessment 26(2-3): 165-174.

Renewed interest in urban forestry has resulted in significant public investment in trees during the past few years, yet comprehensive urban forest monitoring programs are uncommon. Monitoring is an integral component of a program to sustain healthy community forests and long term flows of net benefits. Volunteer-based monitoring will promote continued public involvement and support in community forestry. To overcome constraints to monitoring in urban environments, programs must be personally relevant, socially desirable, scientifically credible, and economically feasible. A three-tiered monitoring approach is presented. Canopy cover analysis documents net gains and losses in regional urban forest cover. Simplified detection monitoring uses trained volunteers to better understand tree population dynamics, while intensive monitoring characterizes urban forest functions and stressors. Implementation of an urban forest health initiative to develop, place, and evaluate monitoring programs is advocated.

Mcpherson, E. G. (1992). "Environmental Benefits and Costs of the Urban Forest." Proceedings of the Fifth National Urban Forest Conference: 52-54.

Raza, S. H., et al. (1991). "Effect of vegetation on urban climate and healthy urban colonies." Energy and Buildings 15(3-4): 487-491.

The role of plants in developing a healthy atmosphere is very desirable in the context of deteriorating environment resulting from increased urbanization, industrialization and improper environmental management. This investigation has attempted to screen plants for their ability to improve the design and development of healthy environments around buildings and urban centres of Hyderabad. Ability index values were computed on the basis of canopy area, physiological characters of trees growing in polluted environments, pollution stress and population load. Azadirachta indica, Pithecolobium dulce and Cassia fistula are suggested for plantations around buildings and urban centres for minimizing pollution. Certain susceptible trees like Pongamia glabra and Polyalthia longifolia have been suggested in the diagnosis and investigation of air quality through biological means.

Smardon, R. C. (1988). "Perception and aesthetics of the urban environment: Review of the role of vegetation." Landscape and Urban Planning 15(1-2): 85-106.

This paper is a review of the role that urban vegetation plays in regard to human behavior and the perception of urban environments. This includes a review of the functions or benefits of urban vegetation to human use-economic benefits, instrumental or physiological functions and perceptual functions including visual, sensory benefits and symbolic aspects. The second part of the paper reviews the roles of urban vegetation in performing these various functions at different environmental scales and in different contexts. Finally, there is a review of means to assess change in the quality of urban vegetation in the environment as well as using vegetation to improve urban environmental perceptual quality.

Mcpherson, E. G., et al. (1988). "Impacts of Vegetation on Residential Heating and Cooling." Energy and Buildings 12(1): 41-51.

Mcpherson, E. G. (1988). "Functions of Buffer Plantings in Urban Environments." Agriculture Ecosystems & Environment 22-3: 281-298.

Westman, W. E. (1977). "How much are natures services worth." Science 197(4307): 960-964.

Stephenson, W. R. and H. G. Merriam (1975). "Some effects of urban impact on the structure of lichen communities on trees in three deciduous woodlot types." Urban Ecology 1(2-3): 311-323.

Variations in the corticolous lichen communities growing on the dominant tree species in certain woodlots were related in degree of exposure to the airborne pollutant complex from an urban center of one half million people (Ottawa, Canada). Sugar Maple (Acer saccharum), Red Maple (Acer rubrum), and Balsam Poplar (Populus balsamifera) woodlots were studied. Percent cover of all lichens, percent occurrence of dominant lichens, species number, and McIntosh's diversity indices were used to compare lichen communities among comparable woodlots with different degrees of exposure and with controls considered to be relatively free of urban influence. Lichen communities showed negative responses to urban influence of low intensity by reduced lichen cover, and, at higher intensities, in species composition and diversity. Local woodlot specific pollutants gave additive effects.

The value of lichen community variations as indicators of pollutant impact on deciduous forest systems is discussed.