Ecosystems services of trees can save costs for cities: the example of Miami

Compiled by: Johannes Förster mainly based on American Forests (2008)

Short title: Multiple benefits of urban ecosystems: spatial planning in Miami, USA

Key Message: Trees deliver multiple ecosystem services. Stormwater retention by urban forests is worth millions of US$ alone and could saves cost intensive technical solutions. The filtration of air pollutants, carbon sequestration, increased property values, and maintenance of drinking water by urban ecosystems provide further significant benefits.

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What was the problem?

Policy makers in Miami City and Miami-Dade County were concerned about the negative consequences the loss of urban ecosystems such as forests, wetlands, and green spaces have on the well-being of citizens and a sustainable urban development (Miami Green Commission 2007). Miami-Dade County is part of the Everglades ecosystem characterised by flooded grasslands and events of heavy rainfall with large amounts of stormwater occurring during hurricane seasons. This is in particular a challenge for urban planning.

In the past urban planning focused on the development of grey infrastructure to the detriment of green infrastructure such as forests, rivers and wetlands and the related ecosystem services that were degraded and often lost. Furthermore, hurricanes and a tree disease called citrus canker have substantially contributed to the loss of tree cover. This is resulting in high costs: The spread of impervious surfaces increases the run-off of stormwater aggravating damages and requiring the construction and instalment of expensive infrastructure for channelling and treating stormwater. Forests and wetlands are also critical for recharging the Biscayan aquifer, Florida's sole source of drinking water, and the loss of these ecosystems can have significant negative effects. Ground water quality decreases due to the reduction in the natural filtration provided by soils, forests and wetlands and requires cost intensive technical solutions for purifying drinking water. Poor air and water quality also causes health problems requiring costly treatment (American Forests 2008).

One reason for the loss of ecosystems in urban environments is the lack of integrating ecosystem services in urban planning. GIS (Geographic Information System) applications for spatial planning often do not include information on ecosystem services. Therefore, the benefits of ecosystems and the costs that arise from their loss are insufficiently explored and integrated in land-use policies and decisions.

Which ecosystem services were assessed?

The Miami Green Commission engaged American Forests to conduct an Urban Ecosystem Analysis (Miami Green Commission 2007). The aim was to quantify the impact land use changes have on ecosystems and ecosystem services, to quantify the benefits from ecosystem services, and the costs resulting from their loss. Based on this, decision makers and planners expect to better target investments in the restoration and protection of green infrastructure such as tree cover. This is in particular of relevance for Miami's Tree Master Plan which aims to restore the City's tree canopy to at least 30 percent tree canopy coverage by 2020 (Miami Green Commission 2007).

The analysis focused on the ecosystem services mainly provided by trees. However, wetlands, water bodies, such as lakes and rivers, and open green spaces were also considered in the assessment. The pervious soils of these ecosystems help to reduce the damage by protecting the shore line during storm surges and slow water runoff that contributes to flood mitigation. They also improve the quality of air and water by filtering and degrading pollutants in the canopy of trees, in soils and in water bodies. The sequestration of carbon is contributing to climate change mitigation.

How were ecosystem services assessed and valued?

Recent research has analysed Miami-Dade urban forests and estimated the ecosystem services they provide (Escobedo et al 2010, Zhao et al 2010, Escobedo et al. in review). The tool CITYgreen (2010) was used to assess the impact of land cover changes on ecosystem services for Miami City (48 square miles) and the area of the Miami-Dade County Urban Development Boundary (UDB) (447 square miles), which includes Miami City (American Forests 2008). The tool is based on ArcGIS and it can include remote sensing imagery for the analysis of past land cover changes. For analysing land cover changes in the Miami region Landsat imagery with moderate resolution was used for the period from 1996 to 2006 and high resolution imagery for 2004 and 2006, when Hurricanes Katrina and Wilma hit the area (American Forests 2008).

Based on experience the CITYgreen tool is useful for providing a rough assessment of ecosystem services of trees in cities. However, for a more detailed estimation additional analysis are required in order to increase the level of detail and accuracy. Other tools include the Urban Forest Effects Model UFORE (http://www.ufore.org/) and i-Tree (http://www.itreetools.org/), which have been successfully applied by spatial planners for the assessment and quantification of ecosystem services of trees in numerous cities in the USA and worldwide. Both tools guide planners and decision makers in better integrating ecosystem services provided by trees in the development and implementation of spatial plans for cities.

For equating the monetary benefit provided by ecosystems for stormwater management in Miami City, the current cost estimates by stormwater engineers for Best Practice Management (BPM) using technical solutions were applied. This amounts to an average of US$ 7 per cubic feet of stromwater in residential areas and an average of US$ 11 per cubic feet in commercial/industrial areas (American Forests 2008). The value of trees for carbon sequestration are estimated based on the price per ton of CO_2 and the value of filtered air pollutants by trees (e.g. see Escobedo 2007) is based on the avoided costs related to health problems. Furthermore, the cooling effect of trees reduces the need for air conditioning and related electricity costs. From the analysis of changes in tree cover the changes in selected ecosystem services and their values were assessed.

Results of the ecosystem service analysis

In the year 2008 the canopy cover of Miami Dade County was 12 % (95% trees, 3% palms) (Escobedo et al. in review). The 36 million trees (5 % street trees, 10% public, 85% private) belong to 107 different tree species. All together the trees sequester 564,000 metric tons CO_2 per year worth US$ 2.3 million (based on a carbon price of $4/mt$CO_2$) and store 5.4 million metric tons of CO_2. Furthermore, the trees remove 2,350 metric tons air pollution per year worth US$20 million and the savings due to reduced air conditioning are worth US$ 306,000 per year (Escobedo et al. in review).

Analysis with the CITYgreen tool show that changes in tree cover and ecosystem services were significant in particular in areas surrounding Miami City within the Miami-Dade County Urban Development Boundary (UDB): from 1996 to 2006 tree canopy declined by 17% and open space reduced by 9%, while urban areas increased by 6% (American Forests 2008). Urban development contributed significantly to the loss in tree cover in addition to damages by hurricanes and the tree disease. Damages were greatest between 2004 and 2006 when major hurricanes hit the region. Over this period 130 acres of tree cover were lost in commercial/industrial areas and 639 acres in residential areas (American Forests 2008). The lost capacity for stormwater retention and filtration by the ecosystems is estimated to be 4.7 million cubic feet of stormwater in commercial/industrial areas, and 13.7 million cubic feet in residential areas. Given the cost of replacing this loss with technical solutions for stormwater treatment (see above) the total cost caused by the loss of ecosystem services for stormwater treatment is valued at US$52 million for commercial/industrial areas and at US$96 million for residential areas for 2004 to 2006 (American Forests 2008). Ecosystems also lost their ability to remove 14,500 pounds of air pollution annually, valued at US$36,500 dollars per year. In terms of carbon 83,000 tons of carbon stored in trees were lost relating to a loss in carbon sequestration of 643 pounds annually (American Forests 2008).

As most areas of Miami City were already developed with grey infrastructure before 1996 the changes in tree cover and other ecosystems within the City were smaller. Nevertheless the costs due to the loss of ecosystem services for stormwater treatment were estimated at US$ 2 million in commercial/industrial areas and US$ 6.5 million in residential areas for the period 2004 to 2006 (American Forests 2008).

The analysis of scenarios shows that the savings by investing in ecosystem restoration can be significant: increasing the tree canopy from 16% to 25% replacing open space in a residential area of Miami (District 1) was valued at savings of US$ 119 million in stormwater treatment. In the same district the increase of tree cover from 4.6% to 10% in commercial and industrial areas would provide natural stormwater retention valued at US$ 4.8 million savings (American Forests 2008).

What policy recommendation resulted from examining the ecosystem services?

The information on ecosystem services (Escobedo et al. 2010 and CITYgreen 2010) strengthens the understanding of the benefits natural ecosystems provide for urban areas. Urban planners and policy makers become aware of the importance of urban tree cover for the city's infrastructure. Cost efficient options for using ecosystems for carbon offsets and stormwater management, and the maintenance of air and water quality besides others are highlighted. Escobedo et al. (2010) showed that even though trees sequestered only 2% of all city-wide emissions in the County, they are an effective option for offsetting carbon emissions besides other CO_2 reduction policies such as improved transportation and waste management practices. Thereby environmental regulations and protection goals, like those stipulated in the Miami-Dade County Comprehensive Development Master Plan (CDMP) and in the City of Miami Tree Master Plan, can be met. Information on ecosystem services allows targeting areas for preserving natural forests such as mangroves and pine rocklands, as well as promoting ecosystem restoration such as reforestation. Furthermore, it helps identifying,

where investments into the management and protection of green infrastructure delivers the greatest benefits for urban management and human-wellbeing.

Based on the Miami Tree Master Plan and guided by the findings of studies on the ecosystem services of trees, tree plantings are included in projects administered by the City of Miami, including park management, roadway rehabilitation, traffic calming and flood mitigation. In order to increase tree cover along roads a standard was developed for Transportation Design for Liveable Communities (FDOT) that would promote urban liveability in conjunction with providing a safe and reliable transportation system. It was included in the manual for the Design, Construction and Maintenance for Streets and Highways, also known as the Florida Greenbook (Miami Green Commission 2007).

The reforestation projects take into account key principles of urban forestry for ensuring an appropriate tree selection, proper installation, and long-term maintenance of trees with a certified arborist supervising all projects. As the cost of tree planting ranges between US$ 700 and US$ 1000 per tree the city also develops public-private partnerships in order to generate private investments. A number of successful tree planting events were organised involving the public such as schools and the Neighborhood Enhancement Team (NET). All plantings are recorded in a database to quantify the contribution to the City's tree canopy and in order to better manage the City's green infrastructure and natural assets (Miami Green Commission 2007).

Further information on tools for assessing ecosystem services in cities:

CITYgreen, URL: http://www.americanforests.org/productsandpubs/citygreen/success.php

i-Tree, URL: http://www.itreetools.org/

Urban Forest Effects Model UFORE, URL: http://www.ufore.org/

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