MARYLAND DEPARTMENT OF NATURAL RESOURCES

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A report on Baltimore City's present and potential Urban Tree Canopy

Prepared for:

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City of Baltimore

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Summary

On April 5, 2005, the Maryland Department of Natural Resources (MD DNR) invited Baltimore City to participate in the Urban Tree Canopy (UTC) Goal setting process in accordance with the Chesapeake Bay Program's Riparian Forest Buffer Directive No. 03-01. The Mayor subsequently responded and requested that MD DNR coordinate with City staff to begin the process of investigating the impacts of setting an UTC goal and to start working towards setting a reasonable UTC goal for Baltimore City.

City staff, MD DNR, and representatives from US Forest Service, University of Vermont Spatial Analysis lab, the Parks and People Foundation, and other non-profit groups met during the summer and fall, selected on analyses to be performed, and established timelines for UTC goal setting completion.

Researchers from the US Forest Service and the University of Vermont Spatial Analysis lab coordinated with MD DNR and performed the agreed upon analyses. Using various GIS data, including high-resolution remote sensing data interpreted for trees and other vegetation and parcel information from the Maryland Department of Planning, the team was able to quantify existing UTC and possible UTC by various land use types. Possible UTC was classified into enhancement scenarios based on the 25th, 50th, and 75th percentiles. Results were compared with median UTC for Maryland communities as well as with existing and target UTC for various jurisdictions that have set UTC goals.

As trees and tree crowns take time to grow, UTC planning has a temporal as well as a quantitative element. Twenty to thirty years' time will be needed to achieve a significant increase in UTC.

While it is easy to think of UTC enhancement in terms of planting trees, UTC enhancement requires a combination of tree protection, tree maintenance, and tree planting to be fully realized and efficiently implemented. The impacts of setting a UTC goal will likely include focusing or reallocating of public agency resources (funds, staff, etc.) to enhance UTC on roadside and public Exempt Commercial lands. On private lands, a combination of education and outreach, landowner incentives, and refocusing of regulatory mechanisms (Critical Area Law, Forest Conservation Act, Landscape Ordinance, etc.) to specifically achieve the objectives of the UTC goal will likely be required.

The basic premise of UTC enhancement is water quality improvement related to the Chesapeake Bay. In a study of all (245) small watersheds in Montgomery County, MD, Goetz et al. (2003) found overall of tree cover of 44.6% to be associated with stream health ratings of "good", with increases in overall UTC associated with improvements in stream health ratings and decreases in overall UTC associated with declines in stream health ratings.

We recommend that Baltimore City adopt a 46.3% UTC goal to be attained by 2030 - 2036, with remote sensing assessment of progress in attaining the UTC goal at 10-year intervals. This goal corresponds to the 50th percentile enhancement scenario and slightly exceeds the target established by Goetz (2003).

We recommend that the Baltimore Ecosystem Study (National Science Foundation and US Forest Service) and MD DNR Forest Service work with the City to:

1. Develop a comprehensive urban forest management plan, and
2. Monitor and assess the social and ecological benefits provided by changes in the City's UTC.

*To assist in use of this document, terms that may require explanation are introduced in the body in **bold italics** and defined in the Glossary section. At a hyperlink to a Figure or Table, click on the link and you will go to that Figure or Table. Clicking on the Back button (light blue left arrow in the toolbar just above the document) will return you to your previous location in the text.*

Assignment

The assignment as identified by the client (Baltimore City) was to:

1. Begin the process of investigating the impacts of setting an ***Urban Tree Canopy*** (UTC) goal; and
2. Start working towards setting a reasonable UTC goal for Baltimore City.

Background

The Chesapeake Bay Program's Riparian Forest Buffer Directive No. 03-01 (Chesapeake Executive Council) was signed in December 2003. This expanded riparian buffer directive "...recognizes that urban tree canopy cover offers stormwater control and water quality benefits for municipalities in the Chesapeake Bay watershed and can extend many riparian forest buffer functions to urban settings" and commits to, among others, the following goals:

- By 2010, work with at least 5 local jurisdictions and communities in each state to complete an assessment of urban forests, adopt a local goal to increase urban tree canopy cover and encourage measures to attain the established goals in order to enhance and extend forest buffer functions in urban areas; and,
- Encourage increases in the amount of tree canopy in all urban and suburban areas by promoting the adoption of tree canopy goals as a tool for communities in watershed planning.

On April 5, 2005, the Maryland Department of Natural Resources (MD DNR) sent a written invitation to Mayor O'Malley. The letter invited Baltimore City to be one of the five (5) communities referred to in the directive noted, and committed to provision of technical assistance in the event of acceptance.

At the City's request, a preliminary meeting was held at the City's Department of Recreation and Parks (BDR&P) offices on August 2, 2005.

On August 18, 2005, Mayor O'Malley responded by letter. The letter contained the assignment as described and designated Connie Brown, BDR&P, as the City's point of contact.

On October 18, 2005, the initial goal-setting meeting was held at BDR&P offices. Participants included Baltimore City, MD DNR, US Forest Service, University of Vermont Spatial Analysis lab, the Parks and People Foundation, and other non-profit groups interested in the effort. The group reviewed data and methods, agreed upon certain analyses and set a date to review results and recommend a goal. The timeline called for:

1) An updating of data, methods, analyses, and subsequent report of results by December 15th, 2005;
2) The development of a goal recommendation in early January, and
3) A report to the City by the end of January so the City could have 45 – 60 days for review in order to make an announcement on a UTC Goal by Maryland Arbor Day (the first Wednesday in April), approximately one year from the date of the initial invitation.

On January 5, 2006, the final goal setting meeting was held at BDR&P offices. Participants reviewed and discussed data and analyses noted in the remainder of this report

Methods

Existing And Possible Canopy Cover

Existing UTC was extracted from the MD DNR ***Strategic Urban Forests Assessment*** (SUFA) land cover layer that was created from high-resolution leaf-on ***IKONOS*** satellite imagery in 2001 (Irani and Galvin 2003). Using a geographic information system (GIS) the SUFA layer was overlaid on a composite layer consisting of street and parcel boundaries. Parcel land use type was determined by linking the Parcel data with the MD Property View® dataset. A new land use type, ***Urparian***, was created to describe non-parcel, roadside areas.

To estimate ***possible UTC***, building footprints and water features were added to the above composite layer containing UTC, streets, and parcels. Possible UTC was defined as any piece of land in the city that is not occupied by a building, existing UTC, street, or water. Thus, those areas that are deemed possible include grass and non-road/non-building paved surfaces. There are two limitations to the possible UTC estimates:

(1) The amount of UTC that could be achieved through canopy overhanging streets and buildings is not estimated; and
(2) Non-road/non-building impervious surfaces that could not support overhanging UTC were not removed. It is possible that these two factors could cancel each other out.

Scenarios

Possible UTC was classified into scenarios based on 25th, 50th, and 75th percentiles. Results were compared with median UTC for Maryland communities as well as with existing and target UTC for: Portland, OR (Poracsky and Lackner 2004); Vancouver, WA (Kaler and Ray 2005); Montgomery County, MD (Montgomery County 2000); Roanoke, VA (Urban Forestry Task Force and Roanoke Department of Recreation and Parks 2003); and, Fairfax County, VA (Funders' Network for Smart Growth and Livable Communities 2005).

Results

Land use

Land use types in acres and as a percentage of the total City land area are summarized in Table 1.

Land cover

Land cover as a percentage of the total City land area is depicted in Figure 1.

Existing UTC

Existing UTC by land type in acres and as a percentage of the total City land area is summarized in Table 2. Currently, UTC covers 10,323 acres or 20% of the City. Most UTC occurs on Parcel lands (18%) in contrast to Urparian (2%). The three land use types with the most existing UTC are Residential (7%), Exempt-Commercial (6%), and Urparian (2%). Note that roads are not included in the Urparian category. Roads constitute 13% of the total land area for Baltimore City. If roads were included in Table 2, the Column *Percent of Total Area* would sum to 100%.

Possible UTC

Possible UTC by land type in acres and as a percentage of the total City land area is summarized in Table 3. The five land use types with the largest possibility for increasing canopy cover are Exempt-Commercial (14%), Residential (13%), Urparian (8%), Industrial (8%), and Commercial (7%). Of these five land use types, Exempt-Commercial and Residential already have the highest levels of existing canopy cover.

Discussion

The majority of land area in the City is parcel land (Figure 2). These lands contain the majority of existing UTC as well as the majority of possible UTC. The MD Property View® dataset does not categorize land as public or private. Public lands are primarily found in the created Urparian non-parcel class and in a percentage of the Exempt Commercial (EC) class. The EC class consists mostly of properties owned by the City, the State, nonprofit or charitable organizations (museums, colleges), and private institutions (churches, hospitals). During the implementation phase, we can segregate the public lands within the EC class in order to identify public v. private lands, as they will likely require different approaches for UTC enhancement. The greatest opportunities for UTC enhancement exist on private Residential and Exempt Commercial lands and public Exempt Commercial and Urparian lands, followed by private Industrial and Commercial lands (Figure 3). Though opportunity exists on the remaining seven (7) classes of land types, they each represent no more than 2% of the total possible UTC.

Existing UTC (10,323 acres) covers an area approximately twice the size of all parks in the City (5,072 acres). The maximum possible UTC is 37,928 acres or 73% of City land area, a 267% increase. However, the probability and/or preferability of such an increase is unknown. As a public initiative on public lands only, modest canopy goal increases are achievable through Urparian plantings alone. More significant increases would involve other land use types and owners as policy makers, planners, and managers considered the probability and preferability of different options.

While we may not think of trees in cities as a typical "forest," these trees provide valued services to our daily lives. These benefits include: reducing the urban heat island effect, improving water quality, saving energy, lowering city temperatures, reducing air pollution, increasing neighborhood desirability and quality of life, enhancing property values, providing wildlife habitat, facilitating social and educational opportunities, and providing aesthetic benefits. Scientists now have the ability to qualify and quantify the benefits of UTC. An increase in UTC brings an associated increase in the UTC benefits listed above (US Forest Service *in review*).

The basic premise of this UTC enhancement effort is water quality improvement related to the Chesapeake Bay. In a study of all (245) small watersheds in Montgomery County, MD, Goetz et al. (2003) found overall of tree cover of 44.6% to be associated with stream health ratings of "good", with increases in overall UTC associated with improvements in stream health ratings and decreases in overall UTC associated with declines in stream health ratings. Realizing that the maximum "possible" UTC identified (73%) is not possible for practical purposes, we sought then to identify the maximum probable/preferable UTC in order to attain the desired water quality benefits established by Goetz (2003).

Three possible UTC scenarios were developed for Baltimore City, representing low, medium, and high UTC enhancement:

1. Low: 33.06% UTC (Current UTC + 25% of possible UTC; Table 4)
2. Medium: 46.30% UTC (Current UTC + 50% of possible UTC; Table 5)
3. High: 59.54% UTC (Current UTC + 75% of possible UTC; Table 6).

A comparison of existing and potential UTC under scenarios 1, 2, and 3 to median UTC for Maryland communities and existing and planned UTC in four other jurisdictions that have set UTC goals is found in Figure 4.

As trees and tree crowns take time to grow, UTC planning has a temporal as well as a quantitative element. Twenty to thirty years' time will be needed to achieve a significant increase in UTC.

While it is easy to think of UTC enhancement in terms of planting trees, it is critical that UTC enhancements include a combination of tree protection, tree maintenance, and tree planting in order to be fully realized and efficiently implemented. Luley and Bond (2002) offered the following conceptual analysis for increasing UTC: $C_T = C_B + C_N + C_G - C_M$

Where:

C_T = total UTC in the modeling domain over time (realization of UTC goal);

C_B = the existing UTC;

C_N = UTC increase from new trees (planting);

C_G = the growth of existing UTC (protection and maintenance); and,

C_M = UTC mortality or loss due to natural and man-induced causes.

UTC enhancement can be most efficiently realized by maximizing protection and maintenance in combination with new plantings. A 1999 study by the US Forest Service Northeastern Research Station found that over 65% of the trees in Baltimore were less than 15.2 cm (approximately 6") ***d.b.h.***, and approximately 75% were less than or equal to 22.9 cm (approximately 9") d.b.h. If these trees are managed so that their anticipated mature crown projections are realized, significant UTC enhancement will occur in concert with planting efforts.

The impacts of setting a UTC goal will likely include focusing or reallocating public agency resources (funds, staff, etc.) to enhance UTC on Urparian and public Exempt Commercial lands. On private lands, a combination of education and outreach, landowner incentives, and refocusing of regulatory mechanisms (Critical Area Law, Forest Conservation Act, Landscape Ordinance, etc.) to specifically achieve the objectives of the UTC goal will likely be required.

Recommendations

We recommend that Baltimore City adopt a 46.3% UTC goal to be attained by 2030 - 2036, with remote sensing assessment of progress in attaining the UTC goal at 10-year intervals. This goal corresponds to the 50th percentile enhancement scenario and slightly exceeds the target established by Goetz (2003).

We recommend that the Baltimore Ecosystem Study (National Science Foundation and US Forest Service) and MD DNR Forest Service work with the City to:

1. Develop an implementation plan to realize the UTC Goal (Figure 5).
2. Develop a comprehensive urban forest management plan, and
3. Monitor and assess the social and ecological benefits provided by changes in the City's UTC.

Glossary

d.b.h.: Diameter at breast height (1.4m or 54 in. above the ground). A standard measure of tree size in forestry and arboriculture.

Existing UTC: Any piece of land in the city that was covered by UTC at the time of satellite data acquisition.

IKONOS: A commercial satellite that collects high-resolution imagery at 1- and 4-meter resolution. It offers multispectral (MS) and panchromatic (PAN) imagery. IKONOS was launched on September 24, 1999, and provides imagery beginning January 1, 2000. Space Imaging, Inc. distributes IKONOS imagery under the product name CARTERRA.

Possible UTC: Any piece of land in the city that is not occupied by a building, existing UTC, street, or water. Thus, those areas that are deemed possible include grass and non-road/non-building paved surfaces

Strategic Urban Forests Assessment: UTC assessment process using high-resolution remote sensing imagery. A vegetation mask is created from the NIR-to-Red, (Band4:Band3) ratio image. A texture image of the resulting ratio image is produced to separate UTC vegetation from non-UTC vegetation pixels (separate trees from other vegetation). The resulting image provides for quantification of existing UTC and non-UTC vegetation.

Urban Tree Canopy: Urban tree canopy (UTC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Urparian: Land that falls within the public road right-of-way (PROW), but is not occupied by a road. Typically, it may be considered the land that exists from the edge of a parcel to the edge of a road. Urparian is a land use type definition created for the purpose of this analysis and CBP's riparian focus and is not recognized by MD Property View®.

Figures

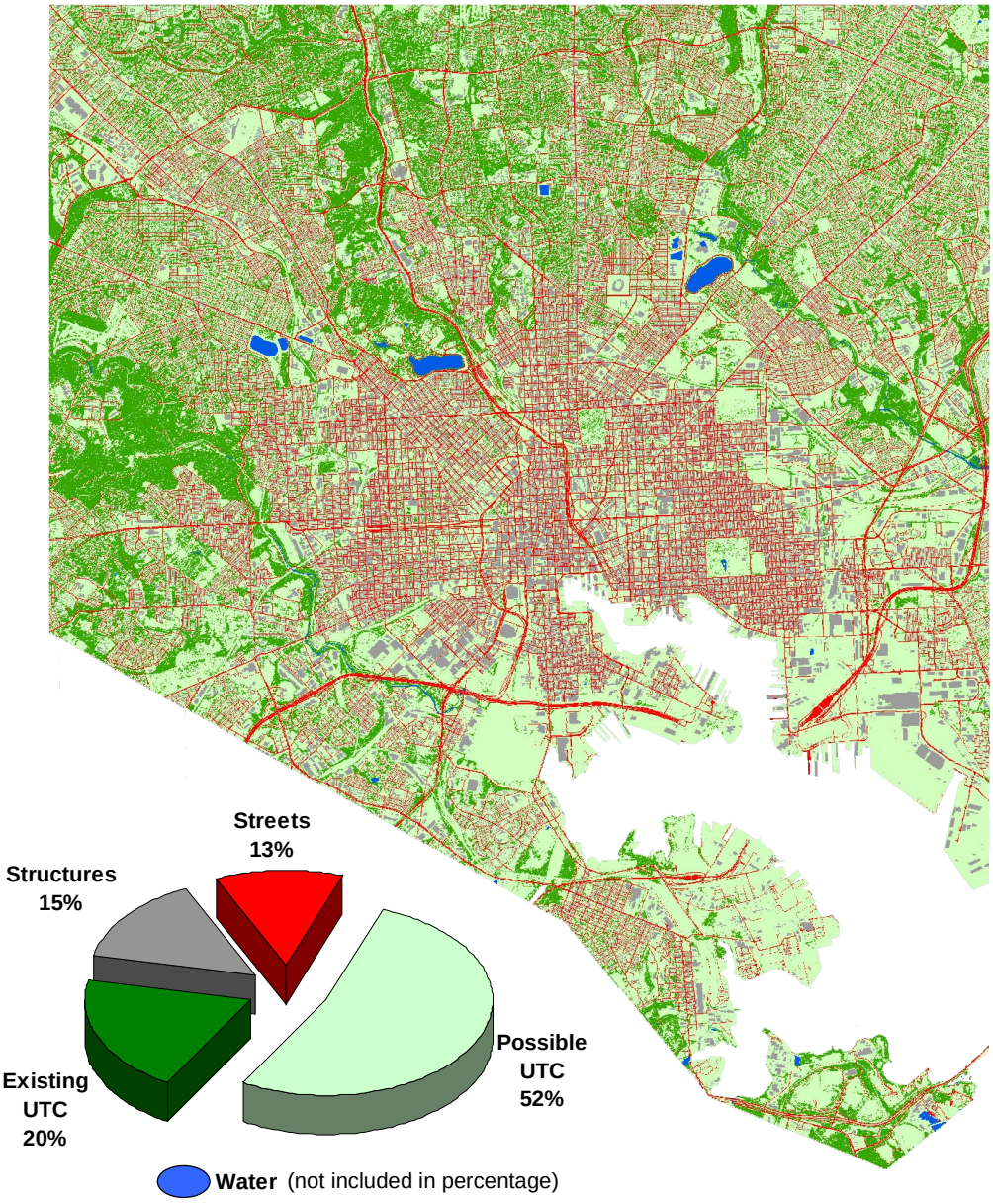

Figure 1 - Existing and possible UTC in Baltimore City

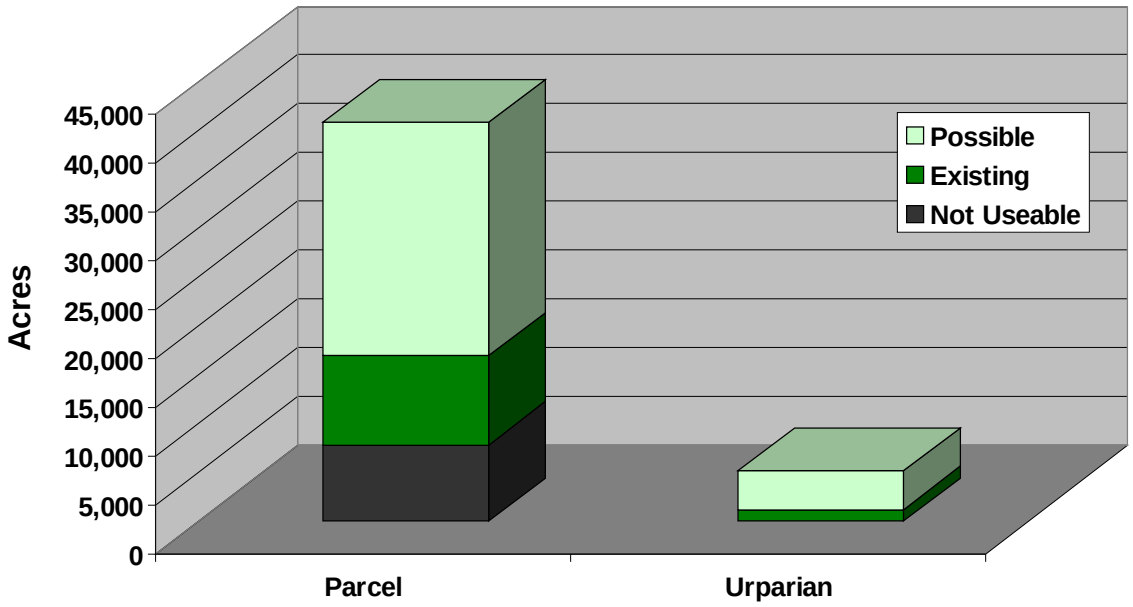

Figure 2 - Existing and possible UTC on Parcel and Urparian lands

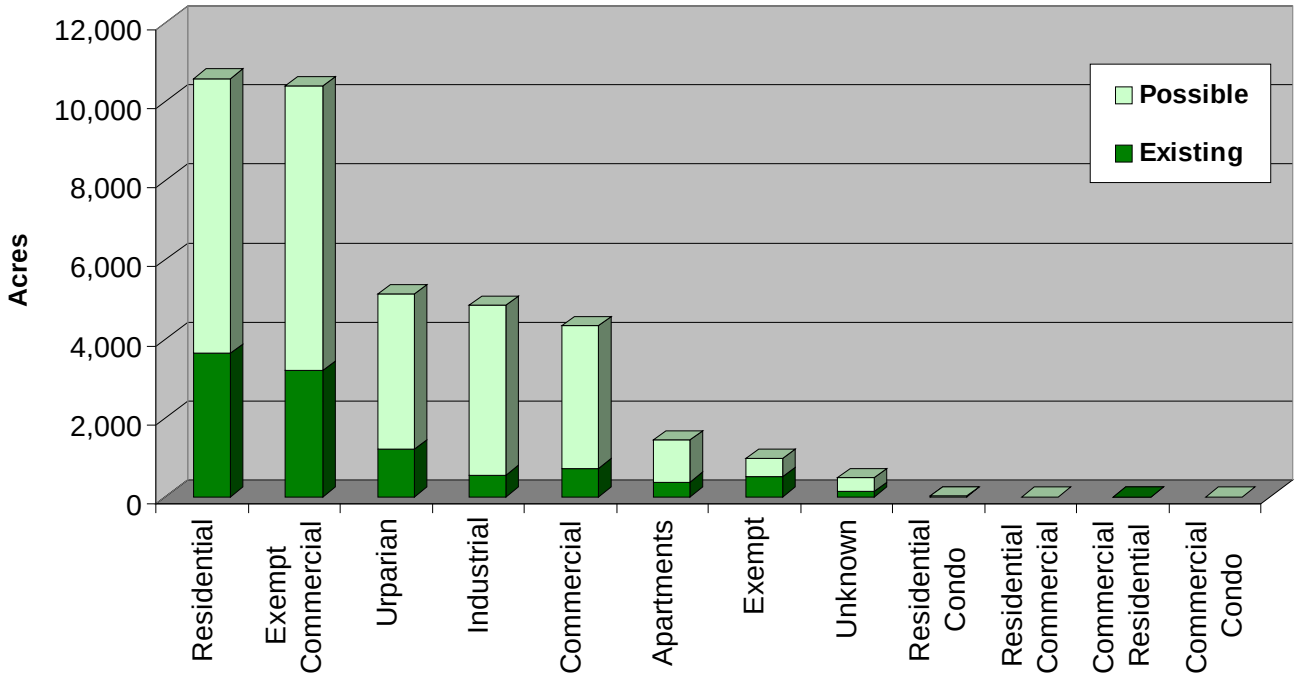

Figure 3 - Existing and possible UTC on parcel lands by land use type

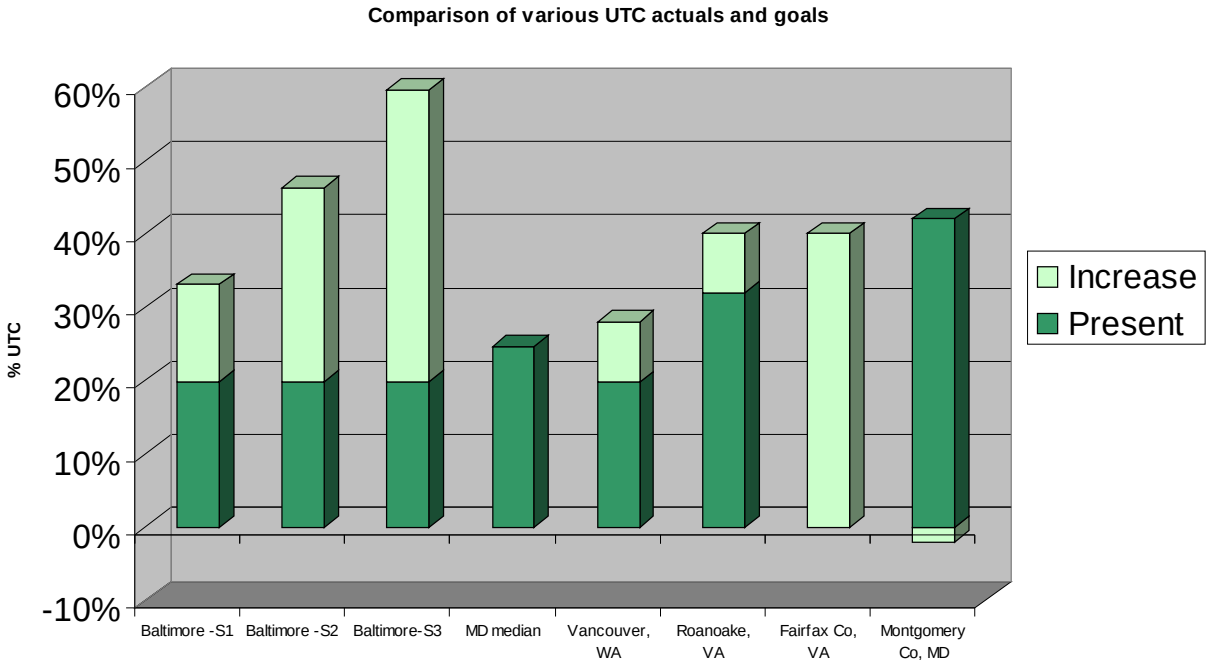

Figure 4- Comparison of UTC among scenarios and jurisdictions

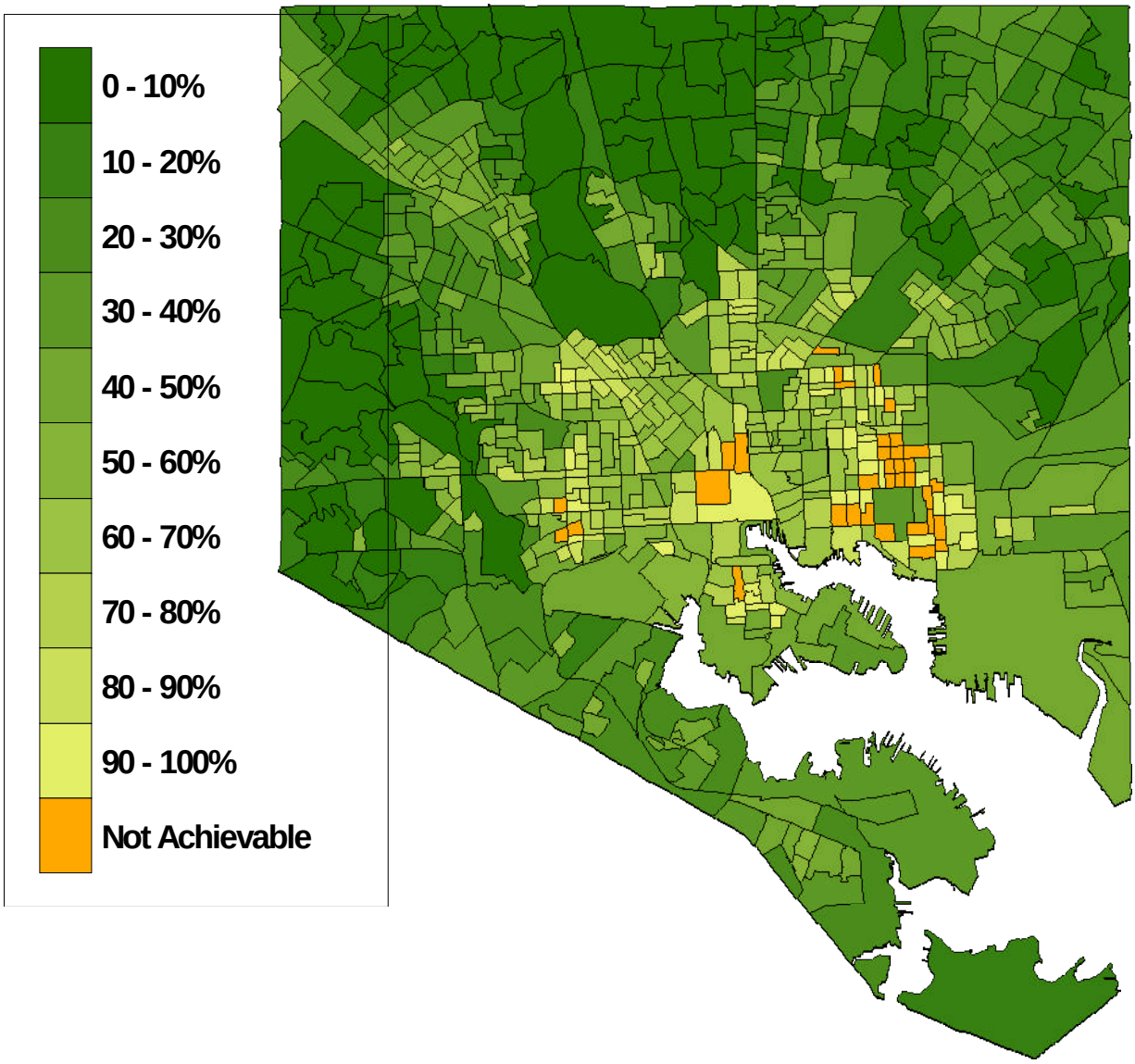

Figure 5 - Percent increase in possible UTC needed to realize UTC goal, per census block

Tables

Land Area		
Land Type	**Acres**	**Percent of Total Area**
City	52,107	
Urparian	4,734	9%
Parcel	40,840	78%
Parcel Breakout by Land Use Code		
Unknown	572	1%
Commercial	5,320	10%
Commercial Condo	2	0%
Commercial Residential	0	0%
Exempt	1,074	2%
Exempt Commercial	11,417	22%
Industrial	6,101	12%
Apartments	1,780	3%
Residential	14,282	27%
Residential Commercial	1	0%
Residential Condo	22	0%

Table 1- Land types in acres and as a percentage of the total City area

Existing UTC		
Land Type	**Acres**	**Percent of Total Area**
City	10,323	20%
Urparian	1,192	2%
Parcel	9,122	18%
Parcel Breakout by Land Use Code		
Unknown	130	0%
Commercial	729	1%
Commercial Condo	0	0%
Commercial Residential	0	0%
Exempt	512	1%
Exempt Commercial	3,187	6%
Industrial	551	1%
Apartments	382	1%
Residential	3,628	7%
Residential Commercial	0	0%
Residential Condo	4	0%

Table 2 - Existing UTC by land type in acres and as a percentage of the total City land area

Possible UTC		
Land Type	**Acres**	**Percent of Total Area**
City	27,605	53%
Urparian	3,936	8%
Parcel	23,897	46%
Parcel Breakout by Land Use Code		
Unknown	344	1%
Commercial	3,587	7%
Commercial Condo	2	0%
Commercial Residential	0	0%
Exempt	453	1%
Exempt Commercial	7,203	14%
Industrial	4,301	8%
Apartments	1,048	2%
Residential	6,950	13%
Residential Commercial	0	0%
Residential Condo	9	0%

Table 3 - Possible UTC by land type in acres and as a percentage of total City land area

	Present condition		Possible increase		Present + Possible		S1: Realize 25% of possible		
Category	**Acres UTC**	**% Total Land area**	**Acres UTC**	**% Total Land area**	**Acres UTC**	**% Total Land area**	**Acres UTC**	**% Total Land area**	**% UTC Increase**
City	10,323	20%	27,604	53%	37,928	73%	17,224	33%	67%
Urparian	1,192	2%	3,936	8%	5,128	10%	2,176	4%	83%
Parcel	9,122	18%	23,897	46%	33,019	63%	15,096	29%	65%
Unknown	130	0%	344	1%	474	1%	216	0%	66%
C	729	1%	3,587	7%	4,316	8%	1,625	3%	123%
CC	0	0%	2	0%	2	0%	0	0%	#DIV/0!
CR	0	0%	0	0%	0	0%	0	0%	239%
E	512	1%	453	1%	965	2%	625	1%	22%
EC	3,187	6%	7,203	14%	10,390	20%	4,987	10%	57%
I	551	1%	4,301	8%	4,852	9%	1,627	3%	195%
M	382	1%	1,048	2%	1,430	3%	644	1%	69%
R	3,628	7%	6,950	13%	10,578	20%	5,365	10%	48%
RC	0	0%	0	0%	0	0%	0	0%	247%
U	4	0%	9	0%	13	0%	6	0%	55%

Table 4 - Scenario 1: Realization of 25% of possible UTC

	Present condition		Possible increase		Present + Possible		S2: Realize 50% of possible		
Category	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	% UTC Increase
City	10,323	20%	27,604	53%	37,928	73%	24,125	46%	134%
Urparian	1,192	2%	3,936	8%	5,128	10%	3,160	6%	165%
Parcel	9,122	18%	23,897	46%	33,019	63%	21,071	40%	131%
Unknown	130	0%	344	1%	474	1%	302	1%	133%
C	729	1%	3,587	7%	4,316	8%	2,522	5%	246%
CC	0	0%	2	0%	2	0%	1	0%	#DIV/0!
CR	0	0%	0	0%	0	0%	0	0%	477%
E	512	1%	453	1%	965	2%	739	1%	44%
EC	3,187	6%	7,203	14%	10,390	20%	6,788	13%	113%
I	551	1%	4,301	8%	4,852	9%	2,702	5%	390%
M	382	1%	1,048	2%	1,430	3%	906	2%	137%
R	3,628	7%	6,950	13%	10,578	20%	7,103	14%	96%
RC	0	0%	0	0%	0	0%	0	0%	494%
U	4	0%	9	0%	13	0%	9	0%	110%

Table 5 - Scenario 2: realization of 50% of possible UTC

	Present condition		Possible increase		Present + Possible		S3: Realize 75% of possible		
Category	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	Acres UTC	% Total Land area	% UTC Increase
City	10,323	20%	27,604	53%	37,928	73%	31,026	60%	201%
Urparian	1,192	2%	3,936	8%	5,128	10%	4,144	8%	248%
Parcel	9,122	18%	23,897	46%	33,019	63%	27,045	52%	196%
Unknown	130	0%	344	1%	474	1%	388	1%	199%
C	729	1%	3,587	7%	4,316	8%	3,419	7%	369%
CC	0	0%	2	0%	2	0%	1	0%	#DIV/0!
CR	0	0%	0	0%	0	0%	0	0%	716%
E	512	1%	453	1%	965	2%	852	2%	66%
EC	3,187	6%	7,203	14%	10,390	20%	8,589	16%	170%
I	551	1%	4,301	8%	4,852	9%	3,777	7%	585%
M	382	1%	1,048	2%	1,430	3%	1,168	2%	206%
R	3,628	7%	6,950	13%	10,578	20%	8,840	17%	144%
RC	0	0%	0	0%	0	0%	0	0%	741%
U	4	0%	9	0%	13	0%	11	0%	166%

Table 6 - Scenario 3: realization of 75% of possible UTC

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