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Historic land-cover at the Vancouver EPiCC experimental sites

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Introduction

This report includes summary statistics and descriptions of the historic land cover fractions ranging from 1930 until 2009 of the two residential neighborhoods, 'Vancouver Oakridge' and 'Vancouver Sunset', which were part of the EPiCC network. The document describes the procedure used to analyze historic aerial photography and estimate the plan area fractions in a 500 m buffer zone around the flux towers of both sites.

As part of the Environmental Prediction in Canadian Cities Network (EPiCC), the University of British Columbia / Department of Geography monitored energy, water and carbon balances in two suburban neighborhoods in Vancouver, BC, Canada in 2008-2011. Two flux towers, 'Vancouver-Sunset' in South-East Vancouver, and 'Vancouver-Oakridge' in South Vancouver, were operated in extensive residential areas composed predominately of single-family homes. Detailed descriptions of the current built and unbuilt landuse fractions of 2009 are presented in other EPiCC Technical Reports (Liss et al., 2010; van der Laan et al., 2011). This report lists historic developments for long-term hydrologic modeling.

Historic Plan Area Fractions

Historic aerial photography was utilized to estimate the plan area fractions for the two urban neighborhoods ranging from 1949 until 2009 in decadal intervals. Table 1 shows the scale and time of capture for each photo representing the end of one decade. The year 1963 was chosen instead of 1959 due to coarse resolution of the air photo that prohibited exact analysis in 1959. Similarly the coarse resolution for the air photos taken in the years 1989 and 1999 was unfavorable for the analysis of the above-ground vegetation plan area fractions, therefore, presently no data for the vegetated and impervious plan area fractions are available for those years.

Table 1 *– List of historic aerial photographs including their month of capture and scale.*

Year	Month	Scale
1949	Mar-Apr	1 : 10 000
1963	Apr-May	1 : 12 000
1969	Mar	1 : 12 000
1979	Jun-Aug	1 : 10 000
1989	Apr	1 : 25 000
1999	Mar	1 : 25 000[(a)]
2009	Apr	1 : 10 000[(a)]

[(a)] estimate based on pixel resolutions of 25 cm (1999) and 10 cm (2009) (City of Vancouver, 2011) and assuming a film resolution of 10 μm

The building plan area fractions λ_b were estimated through the analysis of 2009 BC Assessment data and 2009 LiDAR data (Goodwin et al., 2009). The residual of the built and vegetated plan area fractions, λ_b and λ_v, was assumed to be equal the impervious plan area fraction λ_i. Detailed procedures are explained in Appendix 1 and 2. Table 2 and 3 summarize the obtained historic plan area fractions for the Vancouver Sunset and Oakridge sites, respectively. Due to the absence of LiDAR data for Vancouver Oakridge at the time this report is written, no data is available regarding the plan area fractions of garages and sheds, leading to an overestimation of the impervious plan area fractions in the Vancouver Oakridge study area.

Table 2 *– Historic plan area fractions for a 500 m radius area around the Vancouver Sunset flux tower.*

		1949	1963	1969	1979	1989	1999	2009
$\lambda_{b,SFD}$	Single family dwellings[(a)]	0.20	0.23	0.25	0.28	0.29	0.29	0.29
$\lambda_{b,G}$	Garages and sheds[(a)]	0.01	0.01	0.02	0.01	0.01	0.02	0.02
$\lambda_{b,A}$	Apartments and commercial bldgs.	0.00	0.01	0.02	0.02	0.02	0.02	0.02
$\lambda_{v,G}$	Ground vegetation	0.52	0.48	0.42	0.37	n.a.	n.a.	0.30
$\lambda_{v,T}$	Above-ground vegetation	0.21	0.08	0.09	0.07	n.a.	n.a.	0.06
λ_i	Impervious (including bare ground)[(b)]	0.07	0.20	0.21	0.25	n.a.	n.a.	0.31

[(a)]estimated using building footprint data obtained from LiDAR data
[(b)]distinction between impervious and bare ground was not possible without additional ground-based data

***Table 3** – Historic plan area fractions for a 500 m radius area around the Vancouver Oakridge flux tower.*

		1949	1963	1969	1979	1989	1999	2009
$\lambda_{b,SFD}$	Single family dwellings[(a)]	0.24	0.24	0.25	0.24	0.24	0.25	0.25
$\lambda_{b,A}$	Apartments and commercial bldgs.	0.00	0.01	0.01	0.01	0.01	0.01	0.02
$\lambda_{v,G}$	Ground vegetation	0.32	0.48	0.51	0.42	n.a.	n.a.	0.32
$\lambda_{v,T}$	Above-ground vegetation	0.24	0.12	0.16	0.11	n.a.	n.a.	0.12
λ_{i}	Impervious (including bare ground)[(b)]	0.20	0.16	0.08	0.21	n.a.	n.a.	0.29

[(a)] estimated using digitized building footprint data obtained from the 2009 orthophotos
[(b)] distinction between impervious and bare ground was not possible without additional ground-based data

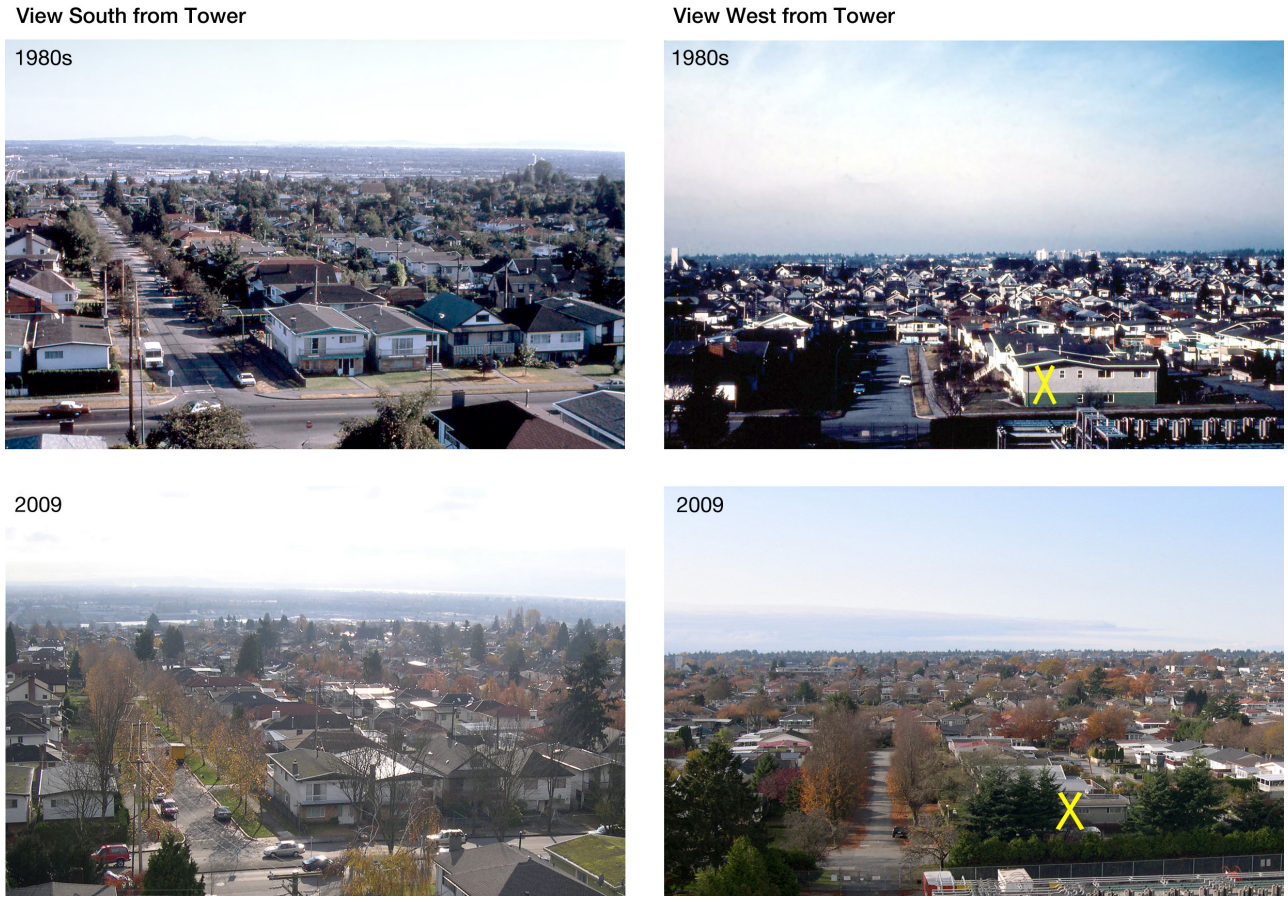

***Figure 1** - Vegetation growth in Vancouver-Sunset as seen on photos taken from tower top in the 1980s and in 2009 (Source: UBC Geography photo archive).*

Appendix 1 – Procedure to estimate vegetated plan area fractions

Preparation of the historic aerial photographs involved the scanning at a resolution that maintained the original image resolution and georeferencing based on the 2009 orthophotos obtained from the City of Vancouver open data catalogue (City of Vancouver, 2010). No orthorectification was performed, however the final loss of accuracy is believed to be small due to largely flat terrain and georeferencing on orthorectified images.

After preprocessing the 500m buffer zones around the flux towers were divided into different sections based on their amount of built infrastructure (i.e. built, partially built, unbuilt). Supervised classification was performed in the unbuilt sections to obtain the above-ground vegetation, ground vegetation and bare ground/impervious plan area fractions. In the built sections a sample set of 3 or 4 housing blocks were digitized to estimate the average vegetated and impervious/bare ground plan area fractions of the typical urban environment. The partially built sections and areas containing apartments, schools, power stations and industrial infrastructure were digitized separately in their entireties. The different plan area fractions were calculated from the total areas of each land use.

Appendix 2 – Procedure to estimate built plan area fractions

For Vancouver Sunset building footprint data was obtained from a previous investigation of LiDAR data (van der Laan et al., 2011). The coupling with 2009 BC Assessment data allowed the calculation of the average footprint for each decade. The aerial photographs were used to count the number of houses per decade and obtain the number of new houses that were added between two subsequent decades. The BC Assessment data provided information of the number of newly built and upgraded houses per decade. From this data the change in footprint from decade X to decade X+1 could be calculated based on the following formulas:

$$\Delta\lambda_u = (B_{nu} - B_n) \cdot (\emptyset\lambda_{X+1} - \emptyset\lambda_u) \quad (1)$$

$$\Delta\lambda_n = B_n \cdot \emptyset\lambda_{X+1} \quad (2)$$

where $\Delta\lambda_u$ is the change in footprint of upgraded houses, $\Delta\lambda_n$ the change in footprint of newly built houses, B_{nu} the number of upgraded and newly built houses obtained from the BC Assessment data, B_n the number of new houses obtained from the aerial photographs, $\emptyset\lambda_u$ the former average footprint of upgraded houses before reconstruction, and $\emptyset\lambda_{X+1}$ the average footprint of decade X+1, respectively. Since the footprint of the houses before reconstruction was not known an average value of all footprints of the previous decades was assumed for $\emptyset\lambda_u$. The total footprint of the 2009 decade was 29% of the total 500 m buffer area (van der Laan et al., 2011), and the total footprint from earlier decades was calculated as following:

$$\lambda_X = \lambda_{X+1} - (\Delta\lambda_u + \Delta\lambda_n)_{X,X+1} \quad (3)$$

where λ_X and λ_{X+1} are the total footprint of decade X and X+1, respectively, and $(\Delta\lambda_u + \Delta\lambda_n)_{X,X+1}$ the sum of the changes in footprint of upgraded and new houses from decade X to X+1. The built plan area fractions were calculated by dividing the total building footprints by the total 500 m buffer area. The same approach was used to estimate the plan area fractions of garages and sheds in Vancouver Sunset.

For Vancouver Oakridge no LiDAR data was available, therefore the average building footprints were estimated

by digitizing the footprints of buildings built in the specific decades from the 2009 orthophotos. No buildings from the 1970-79 decade were still present, therefore in this decade the average footprint was assumed to be the average of the 1964-69 and 1980-89 decade. Further no information regarding the footprints of garages and sheds can be obtained following this procedure since the data regarding the year of construction or upgrade of single family dwellings is not transferable to the garages or sheds seen in the 2009 orthophotos.

The building footprints were slightly overestimated due to additions to houses during upgrades and renovations. Further information regarding upgrades during the first couple decades is lost due to buildings being completely rebuilt in later decades.

References

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