Technological and Higher Education Institute of Hong Kong
香港高等教育科技學院

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Soil Properties in Relation to Tree Performance across Urban Green Space (UGS) Types in Hong Kong

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- PhD in Biology, The Chinese University of Hong Kong

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- Tree management, Urban forestry, Urban horticulture, Landscape ecology, Restoration ecology, Botany

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- Professional Member of Arboricultural Association, UK
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BACKGROUND

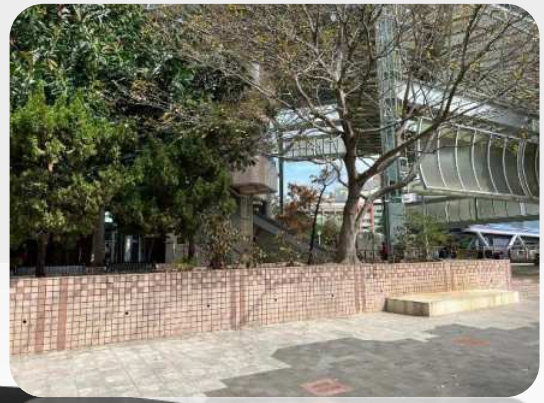
Importance of Urban Green Space (UGS)

- Recreation and human health
- Biodiversity conservation
- Cultural and social benefits
- Regulating services

BACKGROUND (Cont'd)

Hong Kong

- Population: nearly 7.5 million (~6700 people per km^2)
- ~66% of its areas are woodland, shrubland and grassland (mostly located at sub-urban/countryside conservation area)
- Only 1/4 of the total territory's area is suitable for built-up areas and development
- UGS development is greatly hampered by the spatial limitations



(Jim 2000; Jim 2004)

BACKGROUND (Cont'd)

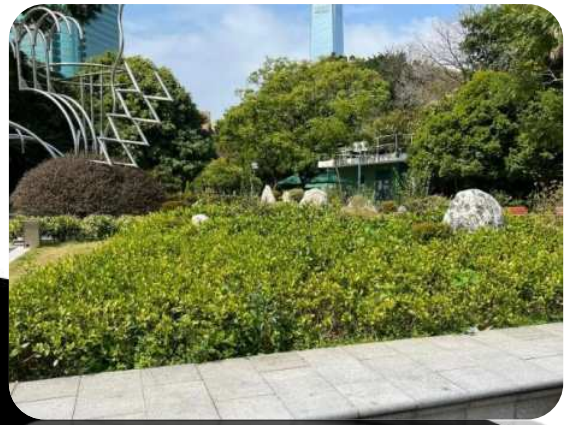
Problems of UGS in Hong Kong

- Physical limitations and chemical inadequacies of roadside and urban park soils: high bulk density, low OC content, alkaline pH, low nutrient content (Jim, 1998a & 1998b)
- Soil from fill materials: lost natural soil horizons, poor structure for water and nutrient holding (Jim, 1998c)
- Sign of pollution by heavy metals (Jim, 1998c)

BACKGROUND (Cont'd)

Objectives

- To assess the growth performance of trees;
- To quantify soil physiochemical properties and metal contaminants;
- To describe the taxonomic diversity as well as the metabolic functions of soil microbial communities;
- To evaluate mutual effect among tree performance, soil physiochemical properties, microbial communities, and metal contaminations in soils of different UGS types; and
- To provide information to improve the quality and tree performance in a technical way for UGS in Hong Kong



BACKGROUND (Cont'd)

Significance

- To understand the differences of soil properties and microbial communities of major UGS types in Hong Kong
- To advise possible solutions to improve the tree growth and health.

Study sites – five areas

Study sites – five areas

	Urban Park	Roadside
Hong Kong Island (Central and West)	Hong Kong Park	Kennedy Road
Hong Kong Island (East)	Chai Wan Park	Wing Tai Road
Kowloon (East)	Lok Fu (Morse) Park	Chuk Yuen Road
Kowloon (West)	Kowloon Park	Salisbury Road and Canton Road
New Territories	Tsing Yi Park	Fung Shue Wo Road
Tai Po Kau Nature Reserve, Woodland as contrast		

Eight UGS types (habitats)

Urban Park

Grassland (GL)

Level planting bed (LPB)

Tree pit (TP)

Remnant (R)

Roadside

Planting strip (PS)

Level planting bed (LPB)

Tree pit (TP)

Slope (S)

Data collection

Soil Physical Properties:

- Colour characteristic
- Structure and aggregation
- Bulk density
- Particle size

Soil Chemical Properties:

- Soil pH
- Total organic matter (TOC)
- Essential nutrients

Soil metal contaminants:

- Toxic trace elements

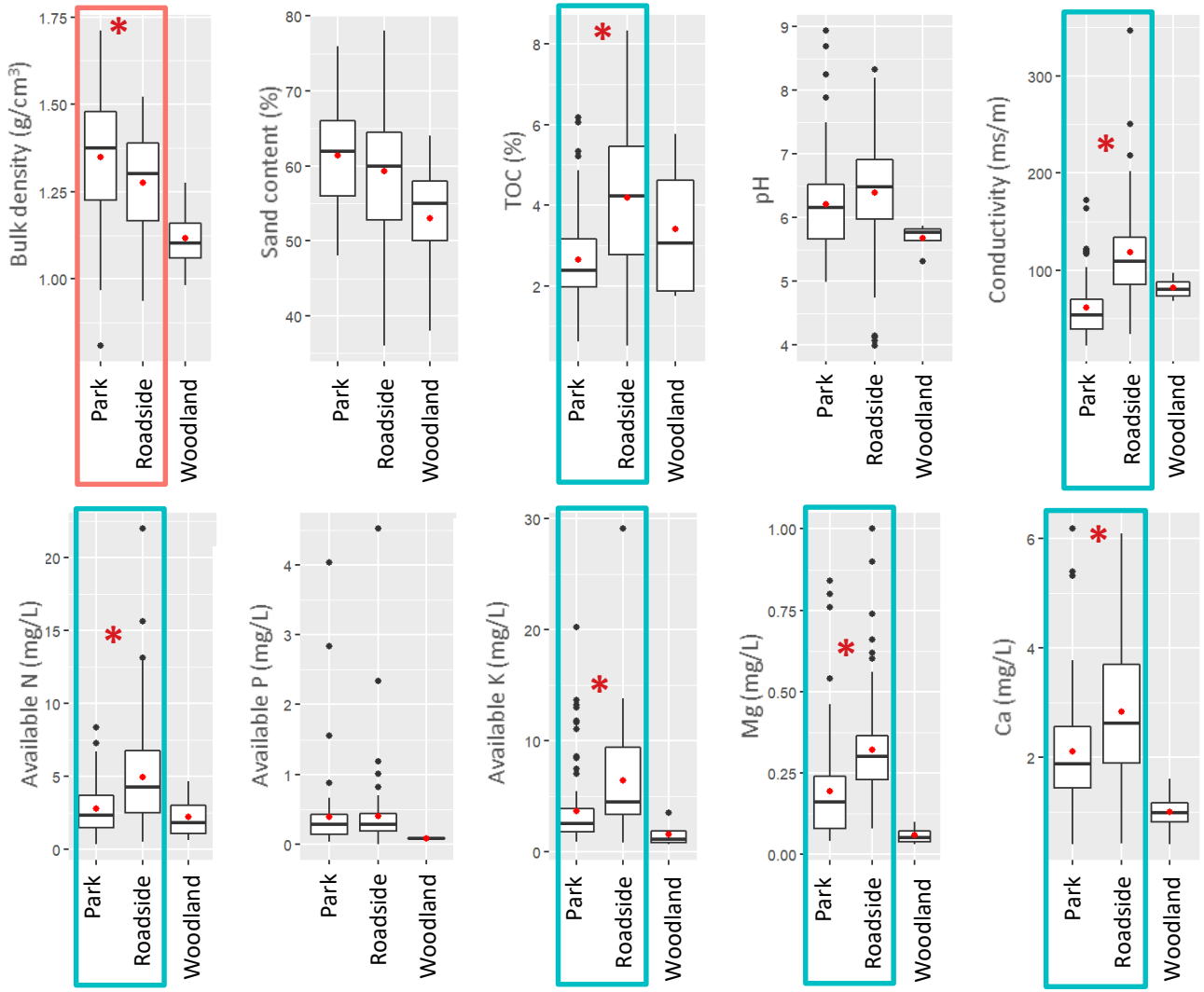
Soil microbial communities:

- Diversity
- Functional profiles

Tree performance:

- Health condition
- Structural condition

RESULTS AND DISCUSSION



Overview of soil properties by sites

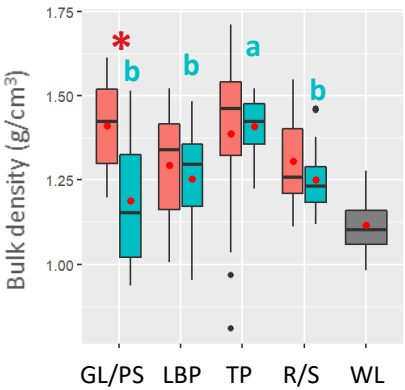
Red dot: mean

* : sig. dif. **between sites (park and roadside)**

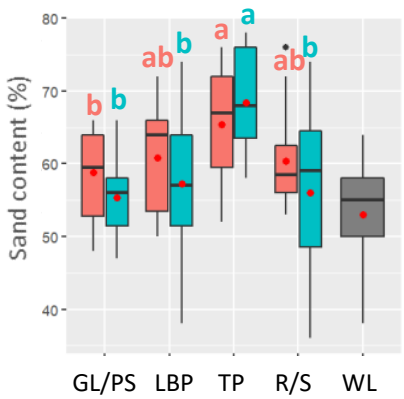
1. **Park soil** with higher bulk density
2. **Roadside soil** showed better performance in general for nutrient-related parameters

RESULTS AND DISCUSSION (Cont'd)

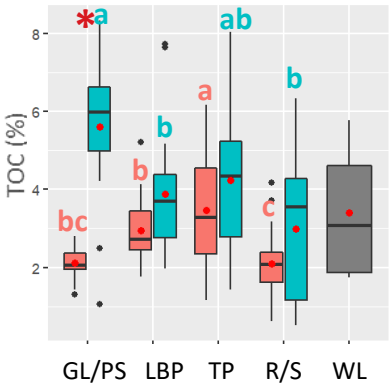
Soil properties by habitats



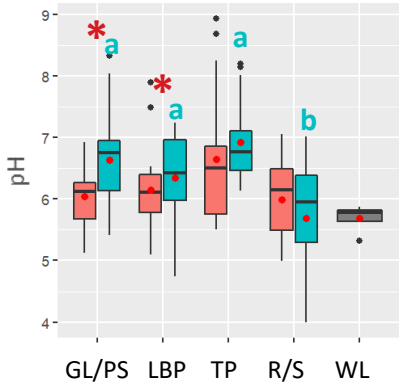
Roadside: high BD at *TP*
VS: high BD at *GL of park*



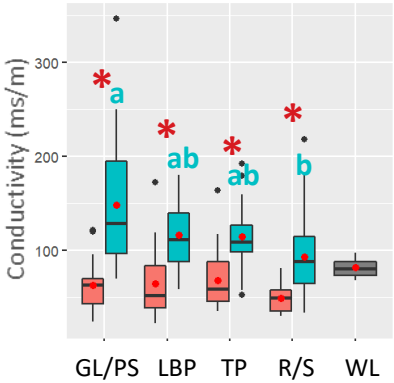
Park & Roadside: higher sand content at *TP at both sites*



Park: lower TOC at *GL* and *R*, highest at *TP*
Roadside: high TOC at *PS*
VS: high TOC at *PS of roadside*



Roadside: lower pH at *S*
VS: lower pH at *GL and LBP of park*



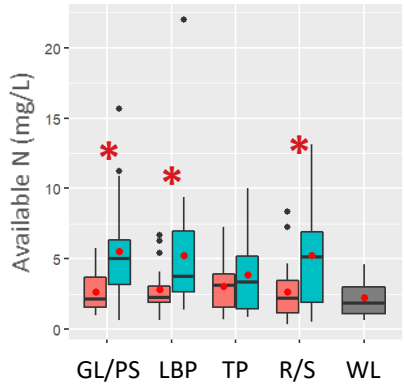
Roadside: highest conductivity at *PS*
VS: high conductivity at *all habitats of roadside*

GL: grassland
PS: planting strip
TP: tree pit
R: remnant
S: slope
WL: woodland (for refere
Habitats of park
Habitats of roadside
Red dot: mean
Different letters **:** sig. dif.
park/roadside sites acro
***** : sig. dif. **between park**
sites for same/similar ha

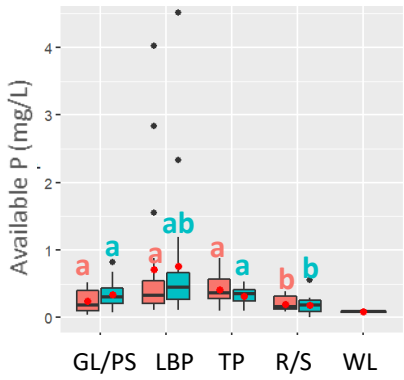
1. High sand content at **tree pit,** for both park and roadside
2. Highest TOC and conductivity at **planting strip of roadside**
3. Higher TOC at **tree pit of park** as compared with grassland or remnant of park
4. Lower pH at **slope of roadside** with as compared with other roadside habitats

RESULTS AND DISCUSSION (Cont'd)

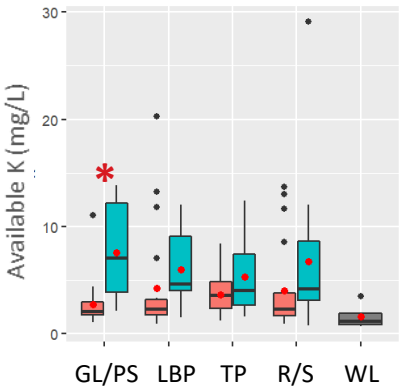
Soil properties by habitats



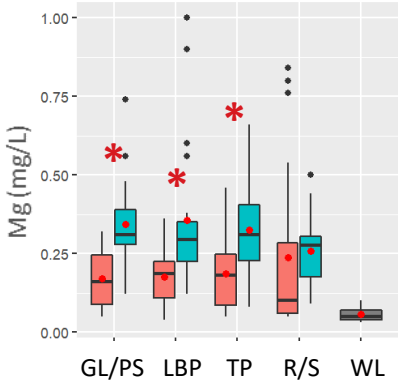
VS: high available N at *roadside* in general



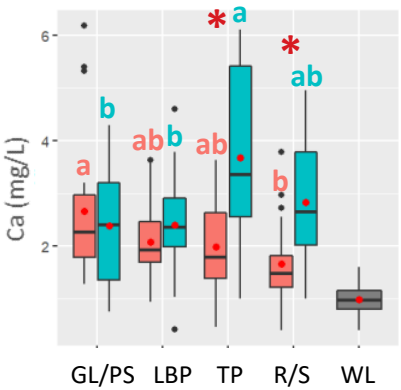
Park and roadside: Lower available P at *R/S*



VS: high available K *at PS at roadside*



VS: higher Mg at *roadside* in general



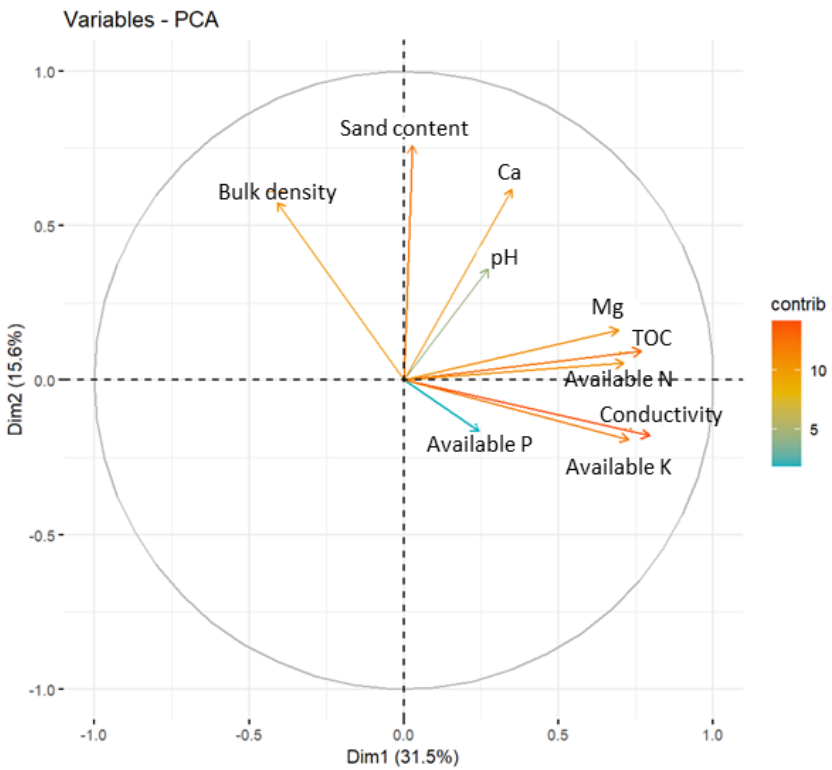
Park: high Ca at *GL*, low at *R*
Roadside: highest Ca *at TP*
VS: higher Ca at *TP and S of roadside*

GL: grassland
PS: planting strip
TP: tree pit
R: Remnant
S: slope
WL: woodland (for referen

Habitats of park
Habitats of roadside
Red dot: mean
Different letters **:** sig. dif. **park/roadside sites** acro
***** : sig. dif. **between park sites** for same/similar ha

1. Lower available P at **remnant and slope** as compared with other habitats in their respective sites
2. **Tree pit of roadside** showed higher calcium content, while **remnant of park** showed lowest calcium content

PCA



PCA loadings

Variable	PC1	PC2
Bulk density	-0.41	**0.58**
Sand content	0.03	**0.76**
TOC	**0.77**	0.09
pH	0.27	0.36
Conductivity	**0.79**	-0.18
Available N	**0.71**	0.05
Available P	0.24	-0.17
Available K	**0.73**	-0.19
Mg	**0.69**	0.16
Ca	0.35	**0.62**

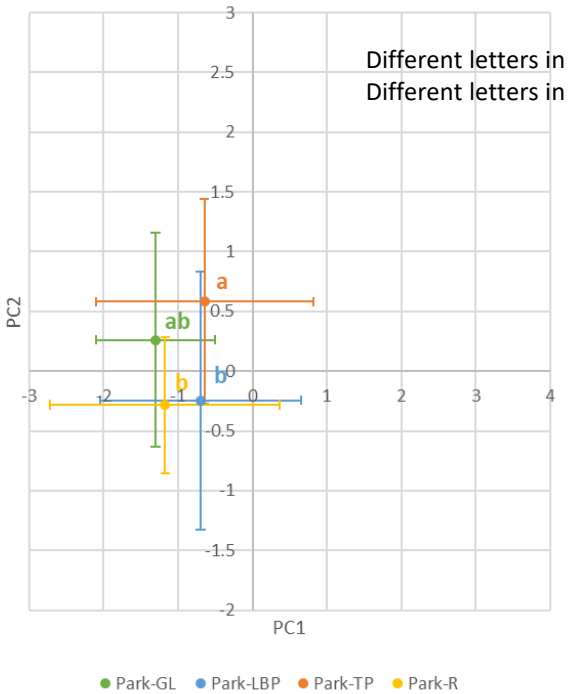
PC1: better nutrient conditions (higher TOC, conductivity, available N, available K and Mg)

PC2: poor physical properties (higher sand content, bulk density and Ca content)

Ca content: may be affected by presence of calcareous construction rubble (Jim, 1998c; Greinert, 2015)

Compare between habitats

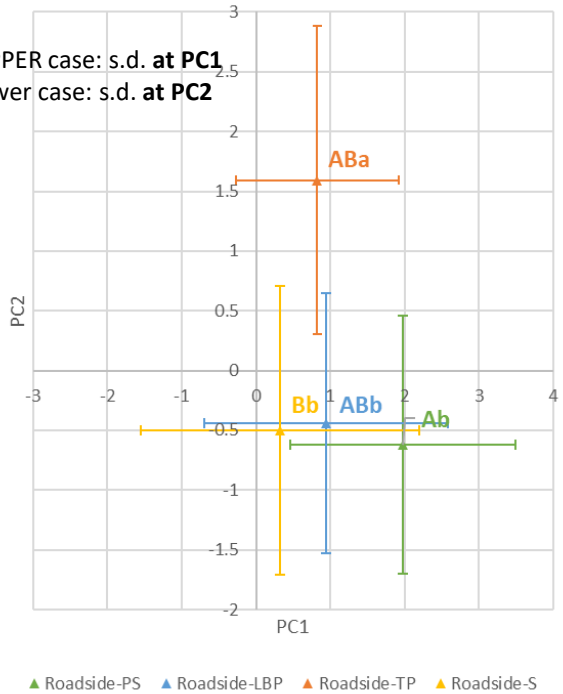
Park



Park
PC2: *TP* with poorer physical properties (*vs R*)

GL: grassland/**PS:** planting strip
LPB: level planting bed
TP: tree pit
R: remnant/**S:** slope

Roadside



Roadside
PC1: *PS* with better nutrient conditions (vs *S*)
PC2: *TP* with poorer physical properties

Across sites

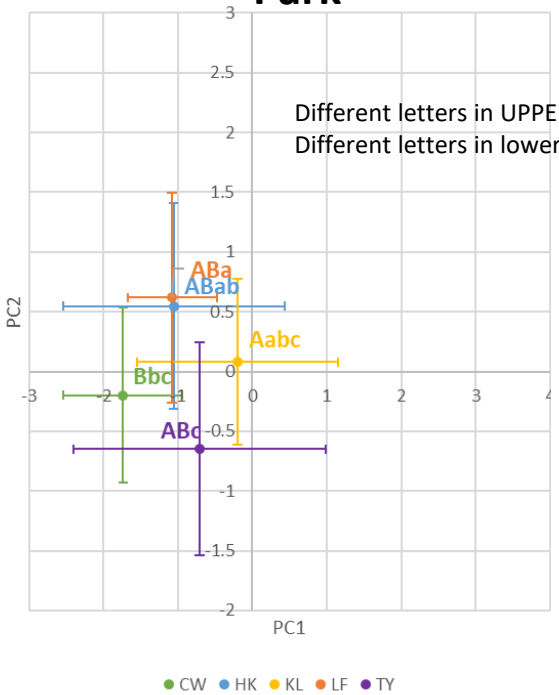
PC	Park	Roadside
	GL	**PS**
PC1	B	A
PC2	a	b
	LBP	**LBP**
PC1	B	A
	TP	**TP**
PC1	B	A
PC2	b	a
	R	**S**
PC1	B	A

Park vs Roadside
PC1: *Roadside* with better nutrient condition
PC2: *TP at roadside* with poorer physical properties than *TP at park*

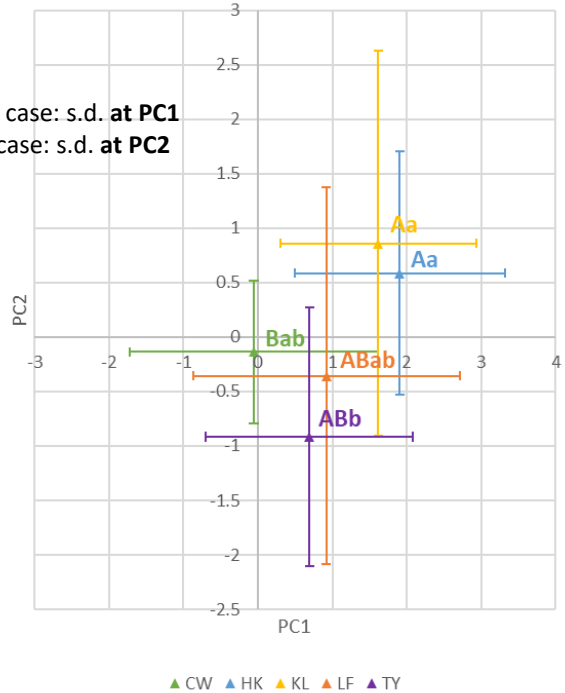
1. **TP** (esp. at roadside) with poorer physical properties
2. **Roadside** showed better nutrient condition, corroborated a Beijing's study (Mao et al., 2014)

Compare between areas (site-level)

Park



Roadside



Across sites

PC	Park	Roadside
	CW	
PC1	B	A
	HK	
PC1	B	A
	KL	
PC1	B	A
	LF	
PC1	B	A
	TY	
PC1	B	A

Park vs Roadside
PC1: *Roadside* with better nutrient condition in *all areas*
PC2: no significant difference

Park
PC1: *KL* with better nutrient conditions (vs *CW*)
PC2: *HK* with poorer physical properties(vs *CW* & *TY*)

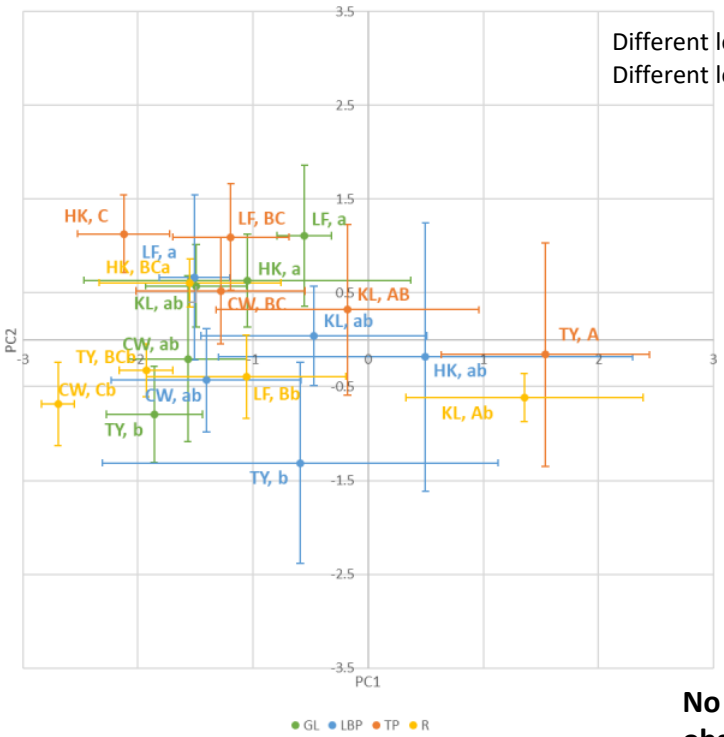
Roadside
PC1: *KL* & *HK* with better nutrient conditions (vs *CW*)
PC2: *KL* & *HK* with poorer physical properties (vs *TY*)

CW: Chai Wan Park – Hong Kong Island (East)
HK: Hong Kong Park – Hong Kong Island (Central and West)
KL: Kowloon Park – Kowloon (West)
LF: Lok Fu (Morse) Park– Kowloon (East)
TY: Tsing Yi Park – New Territories

At both Park and Roadside:
1. Nutrient conditions: **KL** with better, **CW** with poorer
2. Physical properties: **HK** with poorer, **TY** with better

may be contributed by land use/development history of different areas (Pouyat et al., 2010)

Compare between areas (habitat-level)



Different letters in UPPER case: s.d. **at PC1**
Different letters in lower case: s.d. **at PC2**

Four habitats of park

GL
PC2: *LF* and *HK* with poor physical properties (*vs TY*)
LPB
PC2: *LF* with poor physical properties (vs *TY*)
TP
PC1: *TY* with better nutrient conditions (vs *CW, HK, LF*)
R
PC1: *KL* with better nutrient conditions
PC2: *HK* with poor physical properties

GL: grassland/**PS:** planting strip
LPB: level planting bed
TP: tree pit
R: remnant/**S:** slope
CW: Chai Wan Park – Hong Kong Island (East)
HK: Hong Kong Park – Hong Kong Island (Central and West)
KL: Kowloon Park – Kowloon (West)
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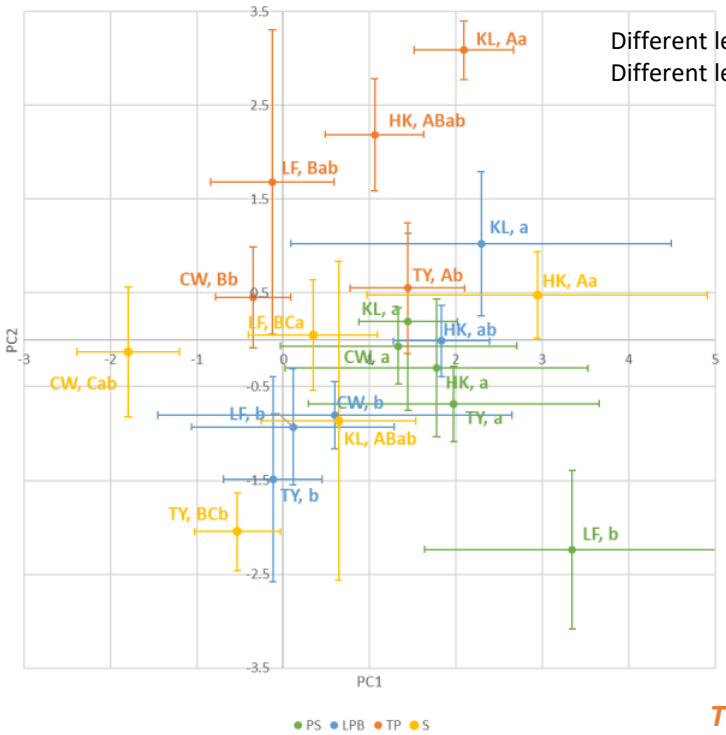
TY: Tsing Yi Park – New Territories

No obvious consistent observations at different areas for variations of soil properties among different habitats of parks.

Across habitats

PC	GL	LBP	TP	R
	CW			
PC1	AB	AB	A	B
	KL			
PC1	B	AB	AB	A
	LF			
PC2	a	ab	a	b
	TY			
PC1	B	B	A	B

Compare between areas (habitat-level)



Different letters in UPPER case: s.d. **at PC1**
Different letters in lower case: s.d. **at PC2**

Four habitats of roadside

PS
PC2: *LF* with better physical properties
LPB
PC2: *KL* with poorer physical properties (*vs CW, LF, TY*)
TP
PC1: *KL and TY* with better nutrient conditions (*vs CW*)
PC2: *KL* with poorer physical properties (*vs CW, LF, TY*)
S
PC1: *HK* with better nutrient condition (*vs CW, LF, TY*)
PC2: *HK* with poorer physical properties (*vs TY*)

Across habitats

PC	PS	LBP	TP	S
	CW			
PC1	A	AB	A	B
PC2	ab	b	a	Ab
	HK			
PC2	b	b	a	b
	KL			
PC2	b	ab	a	b
	LF			
	A	B	B	B
PC2	c	bc	a	Ab
	TY			
	A	B	AB	B
PC1	ab	b	a	b

***TP* showed poorer physical properties at all areas among roadside habitats**
***PS* showed better nutrient conditions among roadside habitats of CW, LF and TY.**

GL: grassland/**PS:** planting strip
LPB: level planting bed
TP: tree pit
R: remnant/**S:** slope
CW: Chai Wan Park – Hong Kong Island (East)
HK: Hong Kong Park – Hong Kong Island (Central and West)
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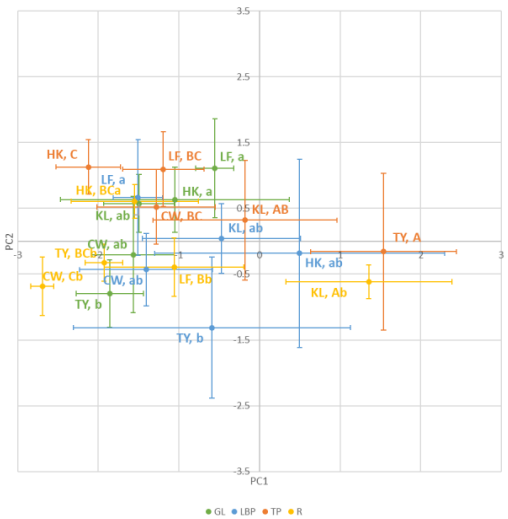
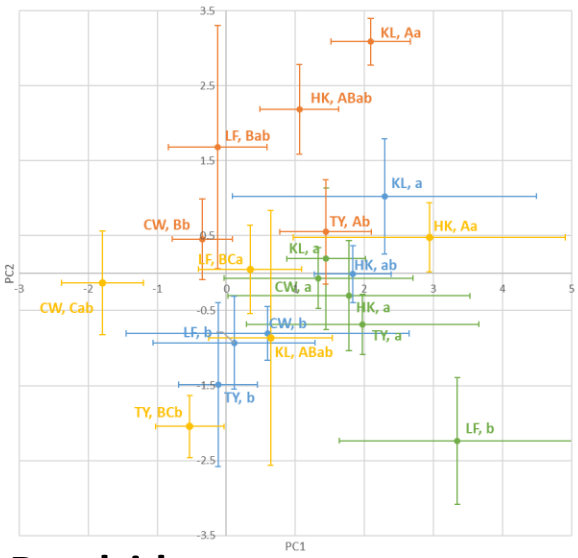
RESULTS AND DISCUSSION (Cont'd)





Park

GL -PC2: *LF* and *HK* with poorer physical properties (*vs TY*)
LPB -PC2: *LF* with poorer physical properties (vs *TY*)
TP -PC1: *TY* with better nutrient conditions (vs *CW, HK, LF*)
R -PC1: *KL* with better nutrient conditions
-PC2: *HK* with poorer physical properties

Roadside

PS -PC2: *LF* with better physical properties
LPB -PC2: *KL* with poorer physical properties (*vs CW, LF, TY*)
TP -PC1: *KL and TY* with better nutrient conditions (*vs CW*)
-PC2: *KL* with poorer physical properties (*vs CW, LF, TY*)
S -PC1: *HK* with better nutrient condition (*vs CW, LF, TY*)
-PC2: *HK* with poorer physical properties (*vs TY*)

Comparison between areas (habitat-level)

1. No significant difference at nutrient conditions for **grassland/planting strip** and **level planting bed**
2. **CW & LF (esp. CW)** showed poorer nutrient condition at **tree pit and remnant/slope,** while **TY** with better nutrient condition **at tree pit for both sites**
3. **TY** showed consistently better physical properties, except for planting strip at roadside
4. **HK** with poorer physical properties **at both remnant/slope, as well as grassland**
5. **KL** with poorer physical properties **at level planting bed and tree pit of roadside**

CONCLUSIONS

- Understanding the differences in soil properties of different urban soils informs management action
- Differences of soil properties between sites:

  -Better nutrient conditions at roadside than park in overall
- Differences of soil properties between habitats:

  -Poorer physical properties at tree pit, together with the more confined space for root development, may pose a great stress for tree growth

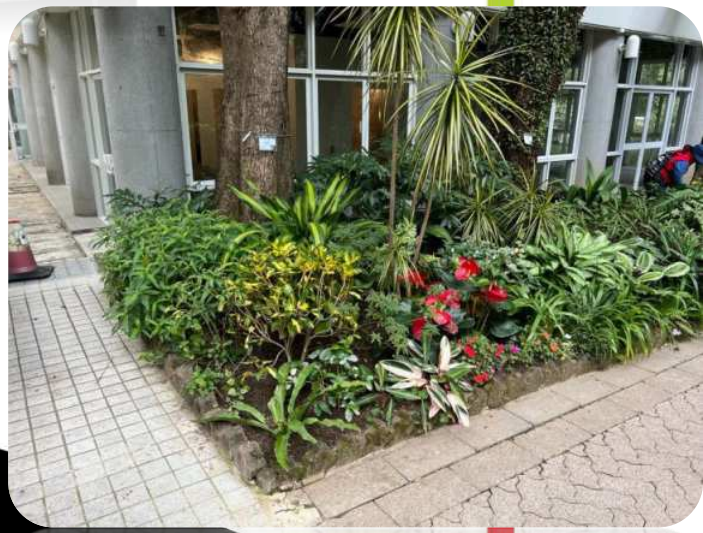
  -Planting strips appeared to be better habitats at roadside in terms of nutrient conditions
- Differences of soil properties between areas:

  -CW with poorer nutrient conditions vs KL with better

  -TY with better physical properties vs HK with poorer

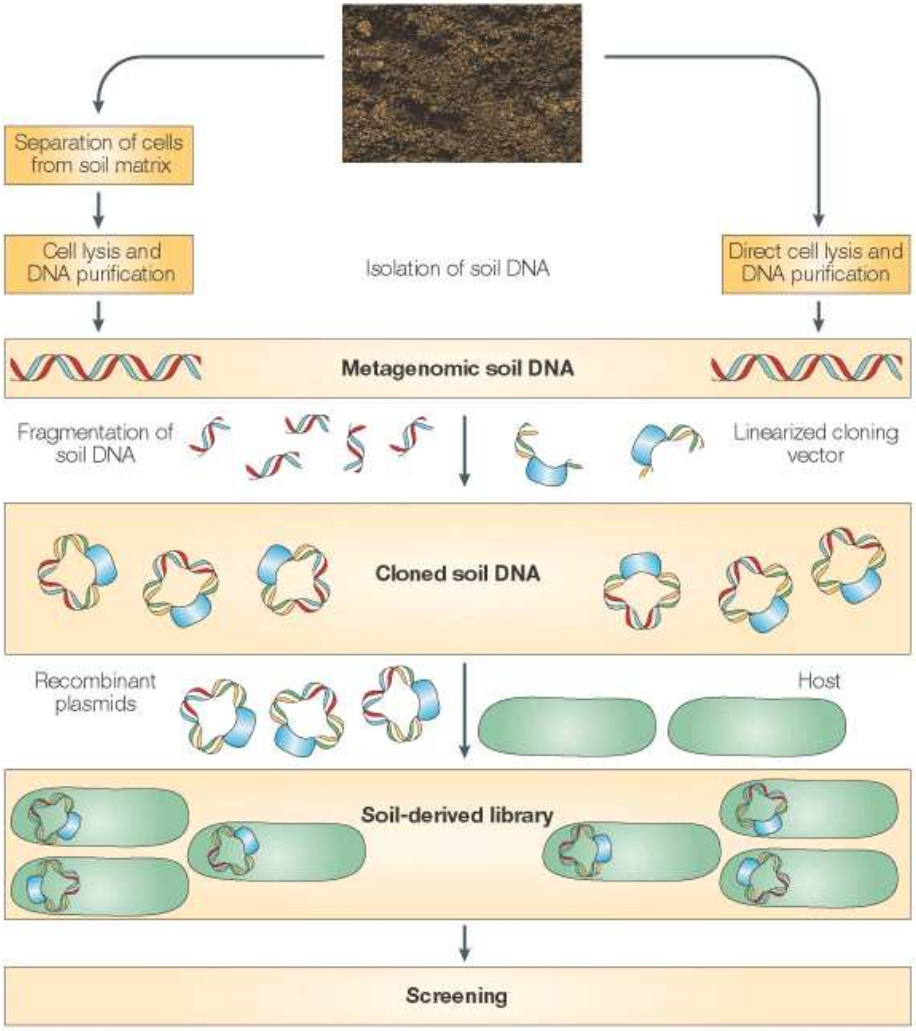
FUTURE STUDY

Tree condition in different UGS types



FUTURE STUDY (Cont'd)

Soil metagenomics sequencing



- 16S & 18S rRNA
- Bioinformatics analysis provided by Majorbio I-sanger Could Platform
- Microbial diversity & function profiles

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路 政 署
HIGHWAYS DEPARTMENT

漁農自然護理署
Agriculture, Fisheries and Conservation Department

發展局
Development Bureau

Thank You