Impacts of urbanization attributes on bird diversity

Jennifer Baez

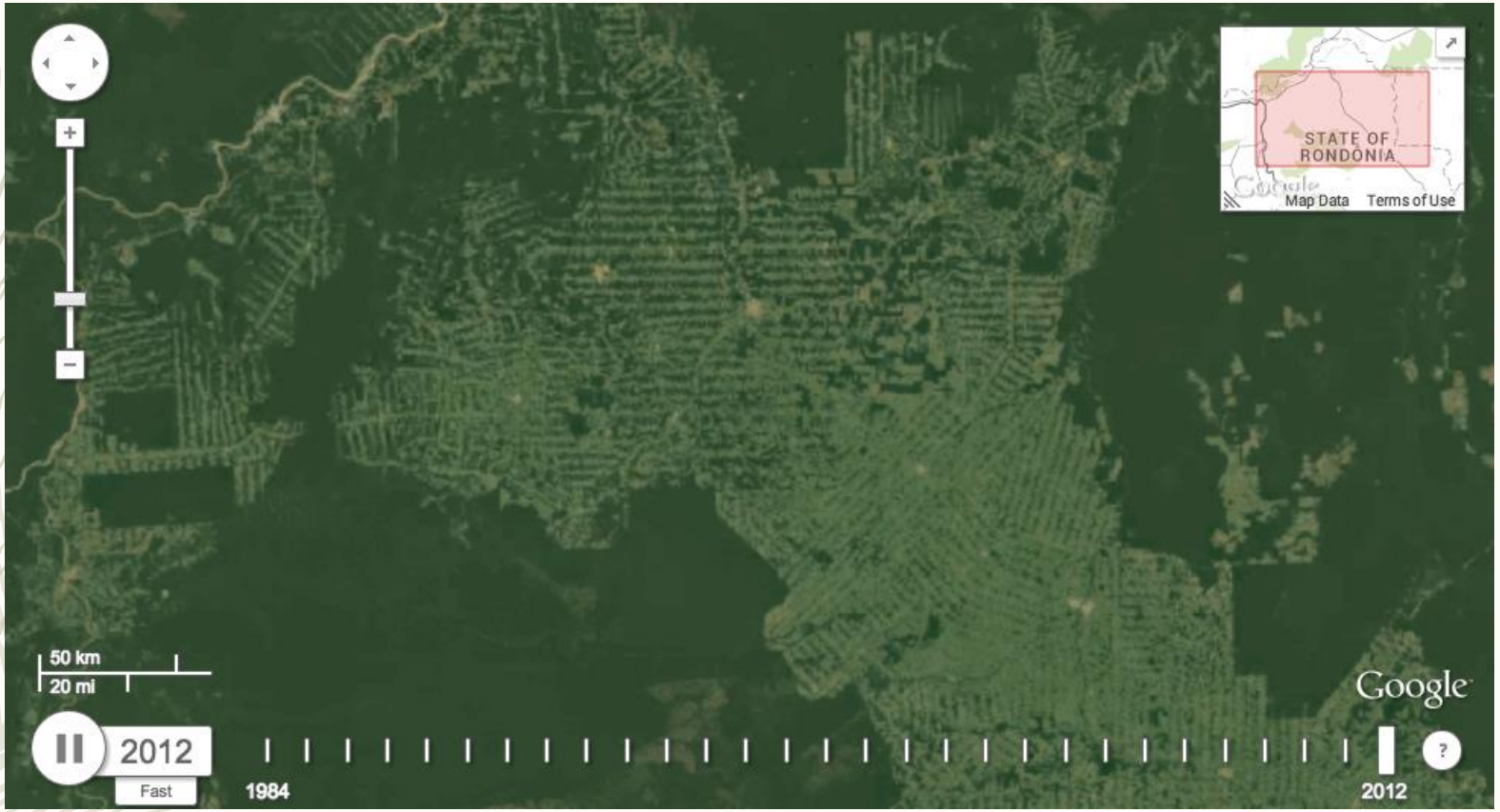
Cheryl Harrison- MARS Fall 2019

Why study how habitat attributes influence bird communities?

1. Understanding what shapes communities is a fundamental goal in ecology.
   - Poorly understood in urban habitats
2. Inform land use and urban planning
3. Urban birds provide many economic and ecological benefits, e.g. ecotourism.

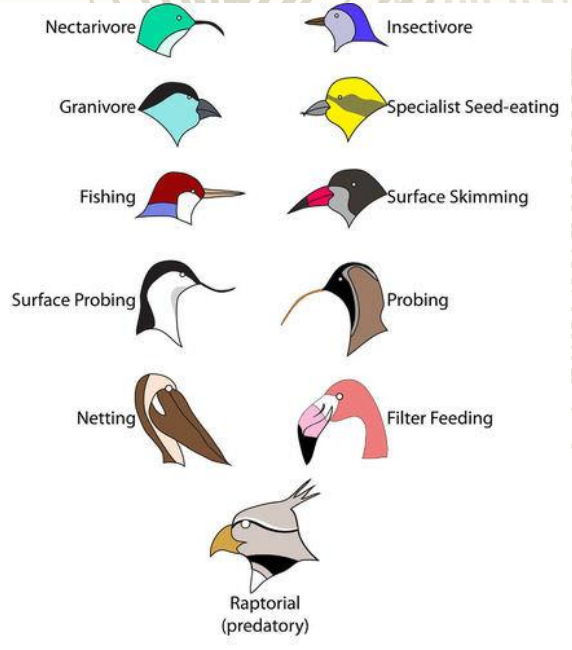
Urban agriculture benefits biodiversity and people.

1. Increase biodiversity in cities
   (green space, habitat complexity)
2. Conserve biodiversity outside of cities
   (less land farmed)
3. Combat hunger and malnutrition
   (more fresh and nutritious food in cities)



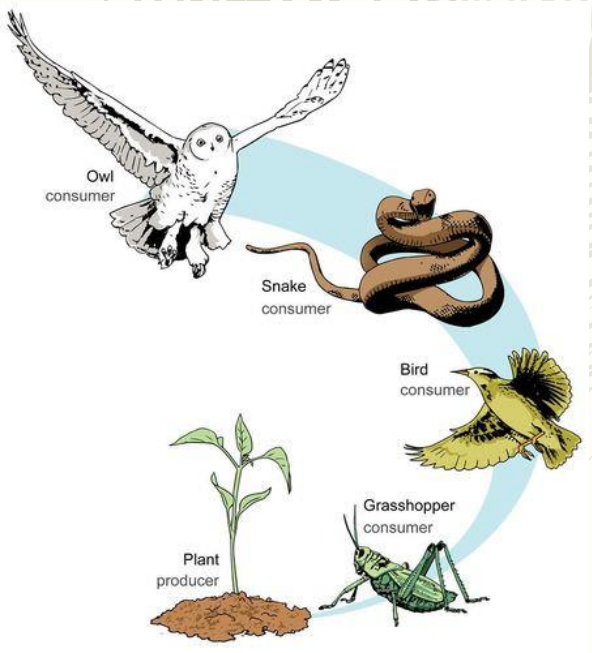
- **Habitat loss** is the main factor driving biodiversity decline.
- **Farming** is the main driver of habitat loss.
- **Human population growth** drives the need for more farms.

Biodiversity matters.



- **Biodiversity is our insurance policy that guarantees the benefits we get from nature will keep coming.**
- Functional *diversity* (different species that do different jobs) provides a greater variety and abundance of ecosystem services for people.
- Functional *redundancy* (multiple species that do the same job) provides resilience in the face of change or disaster.
  - Less likely to stop functioning
  - Faster recovery if functions do stop

Why study birds?



- Flight makes birds a reliable study system.
  - Few geographic boundaries
  - Respond rapidly to changes in land use or local conditions
- Play important ecological roles, for example:
  - Keystone seed dispersers
  - Top-down regulation by avian predators
  - Control pest populations (including many crop pests)
- Fill a diversity of ecological niches and trophic levels (from herbivores to tertiary consumers)
- High economic value (e.g., ecotourism, hunting, & other recreation)
- High cultural & aesthetic value

Agriculture and birds are critical issues in the Rio Grande Valley

- Texas ranks 3rd in annual agricultural cash receipts.
  - Hidalgo ranks 7th and Cameron ranks 24th among all counties in Texas in ag cash receipts (Santa Ana 2011).
- Climate and landscape position make the RGV excellent for agricultural and a 'hotspot' for birds.
- **Bird ecotourism** attracts hundreds of thousands of visitors per year, generating **$463 million** for local economies, and supporting many local jobs (Woosnam et al. 2011).

Hunger and urbanization are critical issues in the Rio Grande Valley

- RGV is one of the fastest growing regions in the US (4.1% population growth rate; USCB 2016).
  - Growth is overwhelmingly in cities
- **1 in 4 people in the RGV are hungry or food insecure.**
- Many RGV urban areas are considered ‘food deserts’.
- Unemployment, poverty, diabetes, & obesity in the RGV are among the highest in the US (USCB 2016).

Key Questions

- Community gardens and other urban farming can:
  - Improve biodiversity inside and outside cities
  - Alleviate hunger and improve access to healthy foods inside cities
- If we are going to invest in urban farming, we want to know how farm/garden features and design influence bird communities.
- <u>Key questions:</u>

  1. **How do habitat attributes influence bird communities?**
  2. **How do community gardens influence bird communities?**

Prior studies on birds and urban habitat attributes

- Bird species vary in their success along an urban-rural gradient (Gilbert 1989, Adams 1994)
- Bird species and other wildlife are often categorized as “urban exploiters,” “urban adapters,” and “urban avoiders” (Blair 2001)
- Even in highly modified environments, bird communities are non-randomly assembled and filtered to contain species with specific niches or adaptations (Johnston 2001)
- Land cover matters; within a habitat type, cover by trees, human structures, etc. can influence bird communities (Evans et al. 2009, Batary et al. 2018)
- Local factors are often more important that regional factors to bird species assemblages and abundance (Evans et al. 2009, Batary et al. 2018)
- ***Specific factors that drive bird utilization in different urban environments remains poorly understood.***

Experimental approach

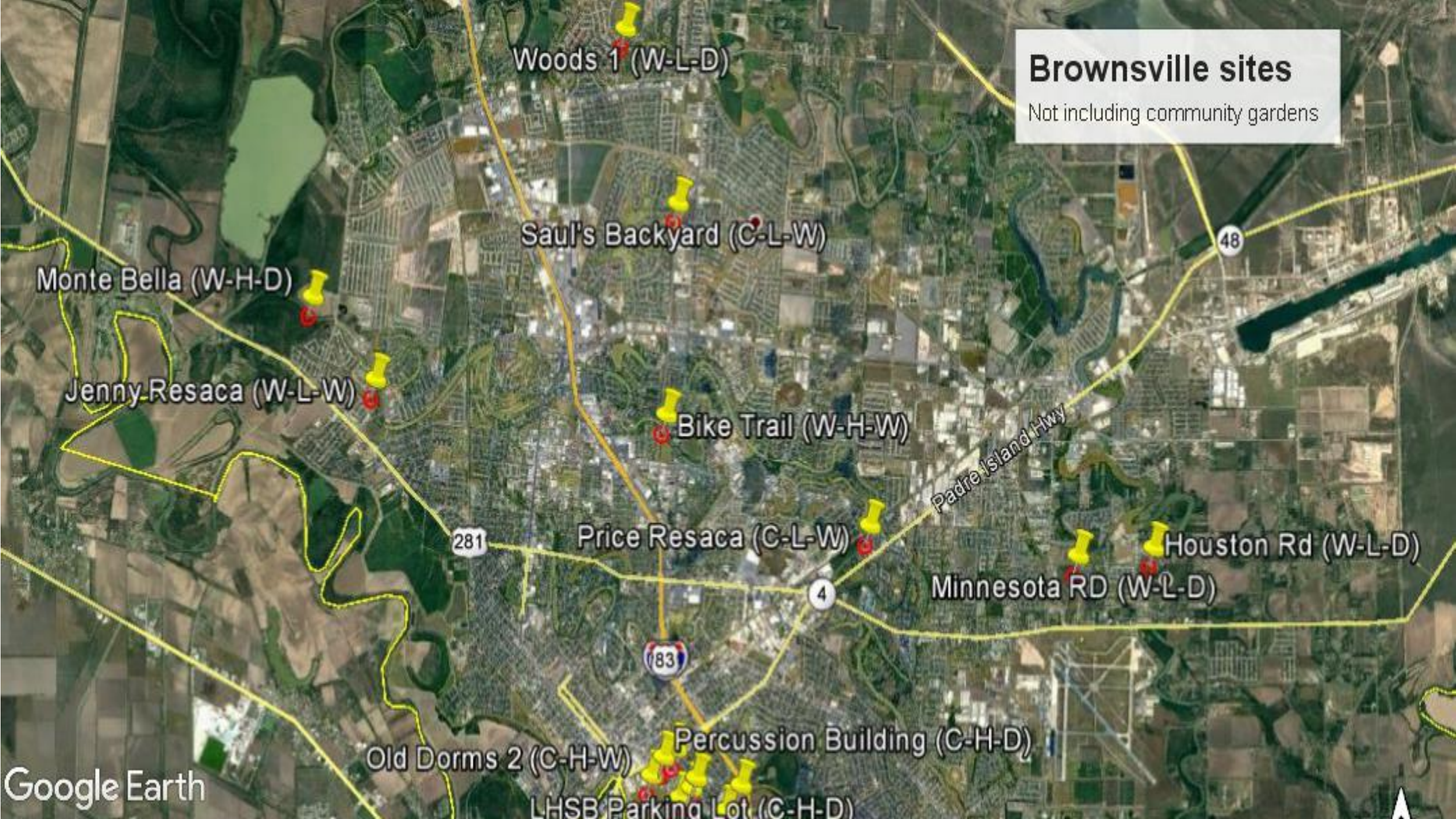
- We identified **three categorical factors**
  - Likely to influence bird communities
  - Change based on human land use
  - Influenced by urban design & planning decisions
- Identified **six land cover classes** (continuous variables)
  - Related to categorical factors
  - Likely to influence particular species or functional groups
- Accounted for two other important factors: sampling date and the city where bird surveys were performed.

Experimental approach

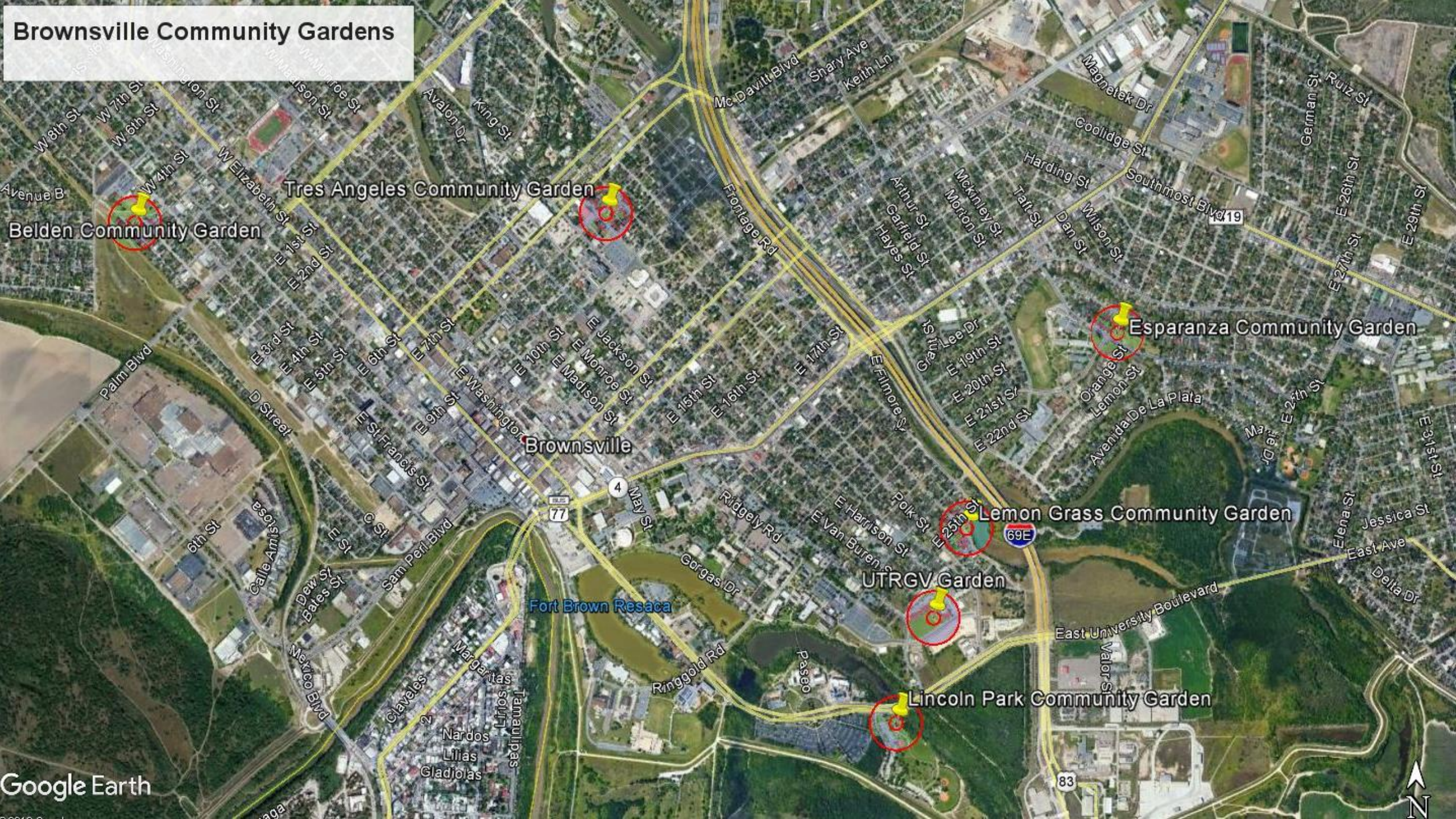
- **Three focal categorical factors**
  1. Habitat urbanity (density of urban features)
     - City: >35% paved surface, human building, or mowed grass cover
     - Wild: <35% paved, building, or mowed cover
  2. Human traffic
     - High: regular human presence or presence of a path or street
     - Low: irregular human presence and absence of paths/streets
  3. Water
     - Wet: A permanent body of water was present
     - Dry: No permanent water present

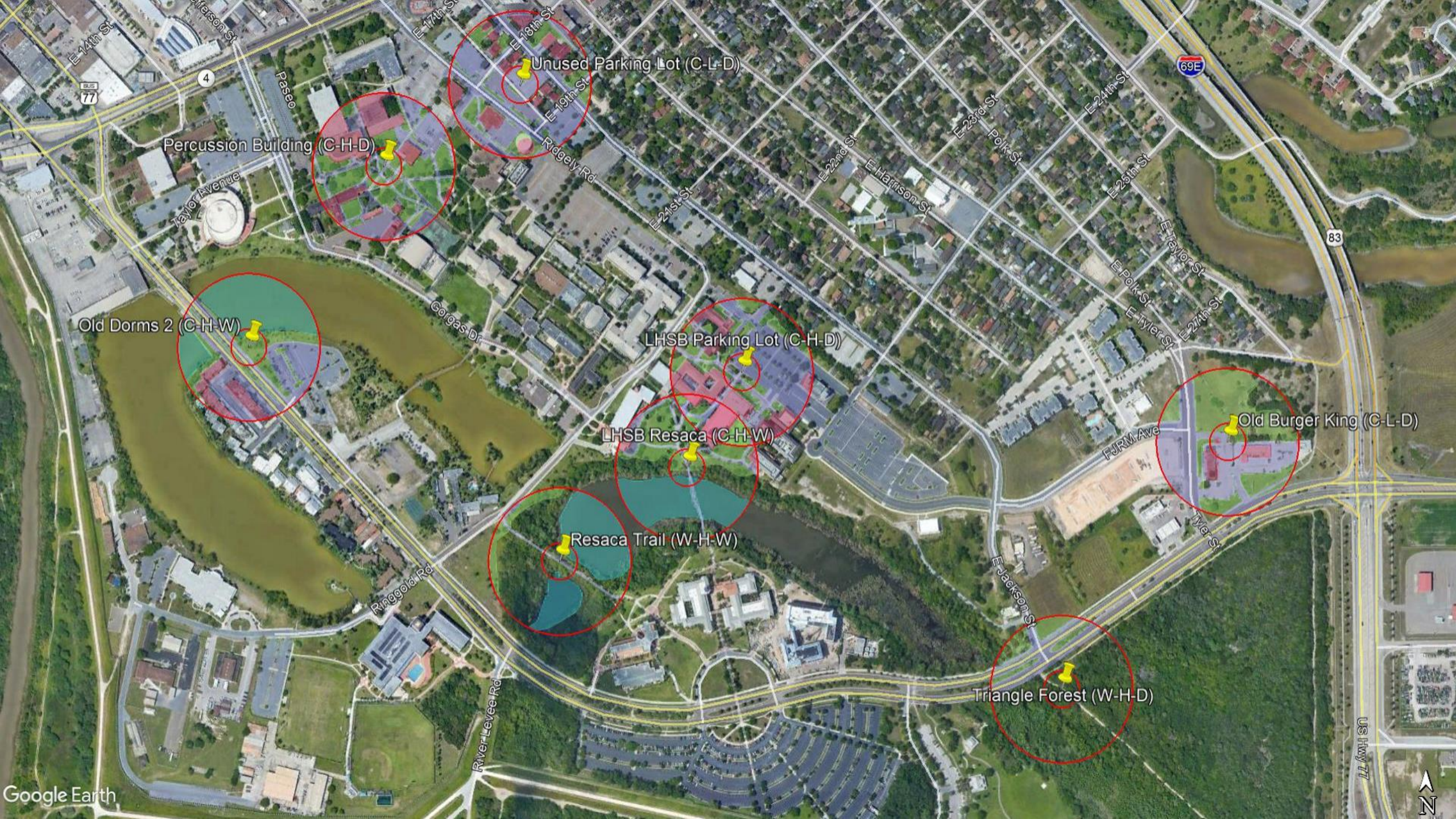
Experimental approach

- **Six focal land cover classes** (continuous variables)
  1. Paved surface cover
  2. Building (human structure) cover
  3. Mowed grass cover
  4. Unmown grass cover
  5. Woody plant (trees & shrubs) cover
  6. Water cover


Brownsville sites
Not including community gardens
Woods 1 (W-L-D)
Saul's Backyard (C-L-W)
Monte Bella (W-H-D)
Jenny Resaca (W-L-W)
Bike Trail (W-H-W)
Padre Island Hwy
Price Resaca (C-L-W)
Houston Rd (W-L-D)
Minnesota RD (W-L-D)
281
4
48
83
Percussion Building (C-H-D)
Old Dorms 2 (C-H-W)
LHSB Parking Lot (C-H-D)
Google Earth

Brownsville Community Gardens




Unused Parking Lot (C-L-D)
Percussion Building (C-H-D)
Old Dorms 2 (C-H-W)
LHSB Parking Lot (C-H-D)
LHSB Resaca (C-H-W)
Resaca Trail (W-H-W)
Old Burger King (C-L-D)
Triangle Forest (W-H-D)
E 14th St
E 17th St
E 18th St
E 19th St
Paseo
Ridgely Rd
Taylor Avenue
E 21st St
Gorgas Dr
E 22nd St
E Harrison St
E 23rd St
Polk St
E 24th St
E 25th St
E Taylor St
E Polk St
E Tyler St
E 27th St
FJRM Ave
Tyler St
E Jackson St
Ringgold Rd
River Levee Rd
US Hwy 77
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Google Earth
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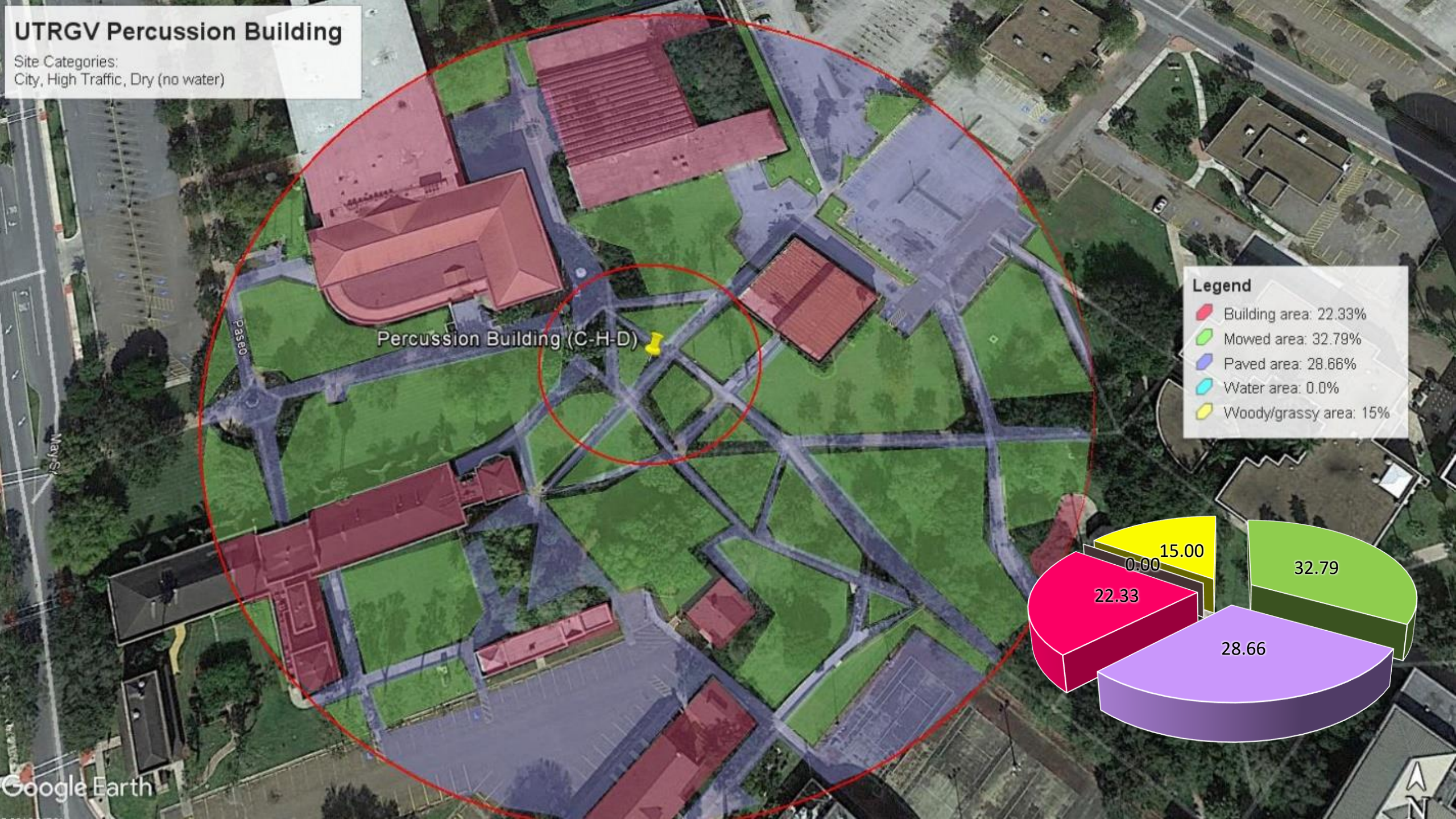
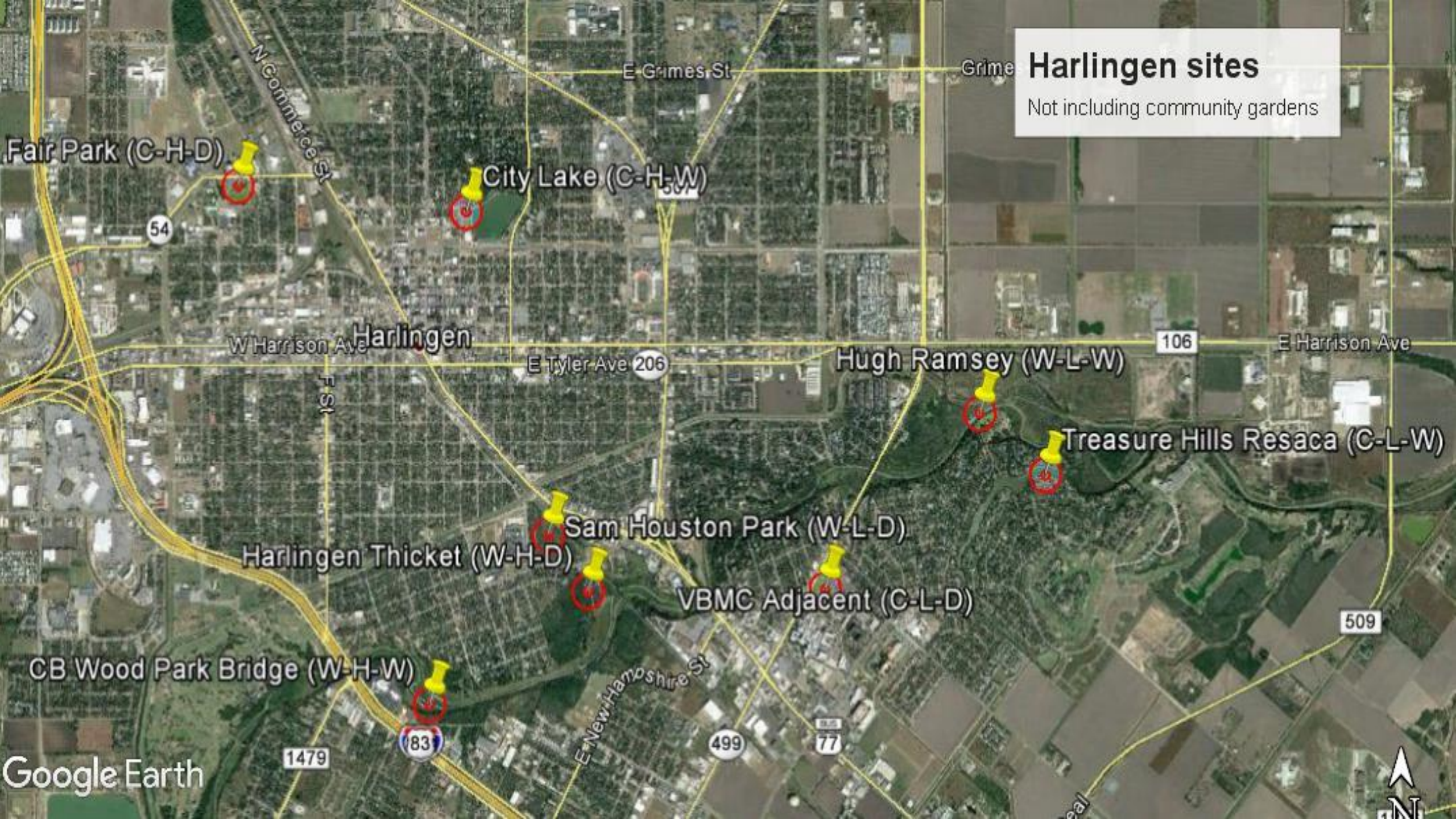
UTRGV Percussion Building

Site Categories:
City, High Traffic, Dry (no water)



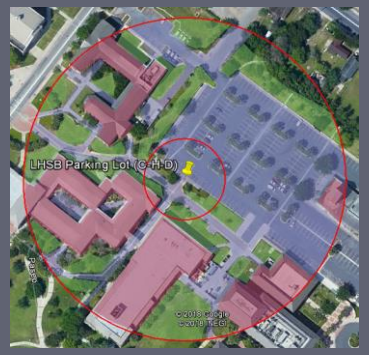

Harlingen sites
Not including community gardens
Fair Park (C-H-D)
City Lake (C-H-W)
Harlingen
Hugh Ramsey (W-L-W)
Treasure Hills Resaca (C-L-W)
Sam Houston Park (W-L-D)
Harlingen Thicket (W-H-D)
VBMC Adjacent (C-L-D)
CB Wood Park Bridge (W-H-W)
E Grimes St
N Commerce St
W Harrison Ave
E Tyler Ave
E Harrison Ave
E New Hampshire St
54
206
106
509
499
77
83
1479
Google Earth

CB Wood Park Bridge
Site Categories:
Wild, High Traffic, Water
CB Wood Park Bridge (W-H-W)
Legend
Building area: 0.0%
Woody/grassy area: 80%
Mowed area: 6.44%
Paved area: 3.02%
Water area: 7.37%
6.45
3.02
7.37
0.00
80.00
Google Earth
N

Point-count surveys

- Survey 25 m-radius sampling areas
  - Minimum 100 m between sites
- Surveys performed from dawn to 10:30 AM
  - Surveys lasted 10 minutes
  - 2-minute “quiet time” before survey
  - 2 minutes of observation, followed by recording (5X)
- Surveys not performed if it was raining or above 88°F
- Preliminary surveys and GIS analyses to quantify habitat characteristics and the six focal land cover values
- Detection surveys performed in 2017 from June to August

Percussion Building (C-H-D)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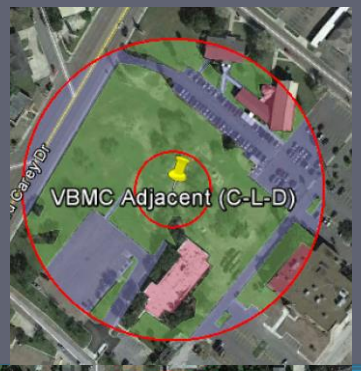
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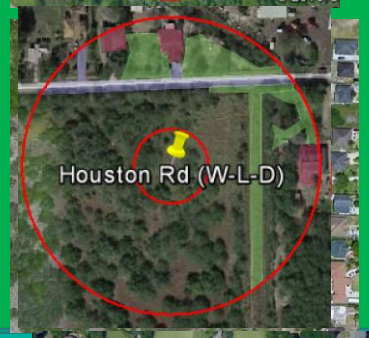
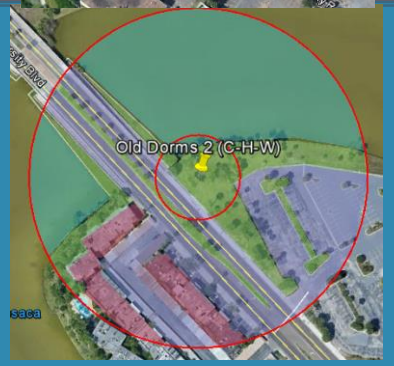
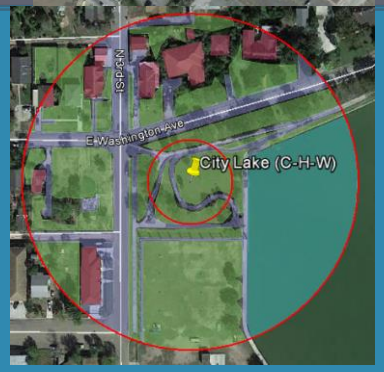
Sam Houston Park (W-L-D)

Woods 1 (W-L-D)


Houston Rd (W-L-D)

LHSB Resaca (C-H-W)


Old Dorms 2 (C-H-W)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CB Wood Park Bridge (W-H-W)

Resaca Trail (W-H-W)

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Saul's Backyard (C-L-W)

Treasure Hills Resaca (C-L-W)

Hugh Ramsey (W-L-W)

Jenny Resaca (W-L-W)

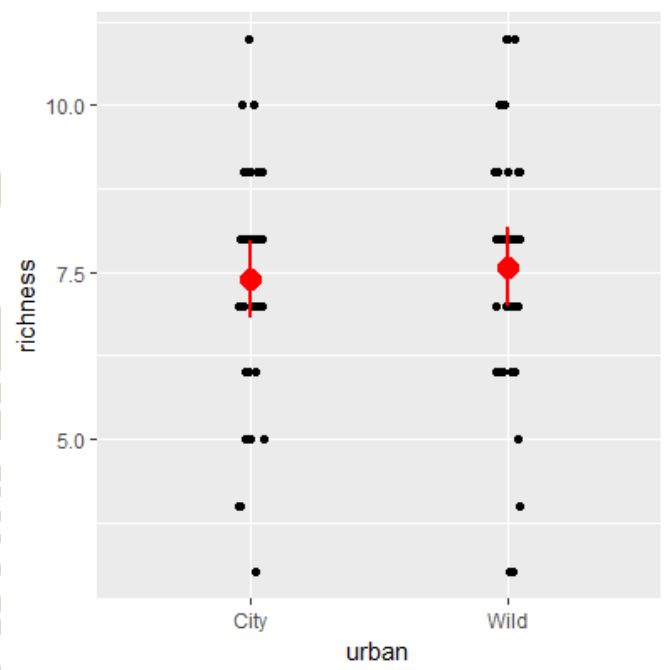
Border Pond (W-L-W)

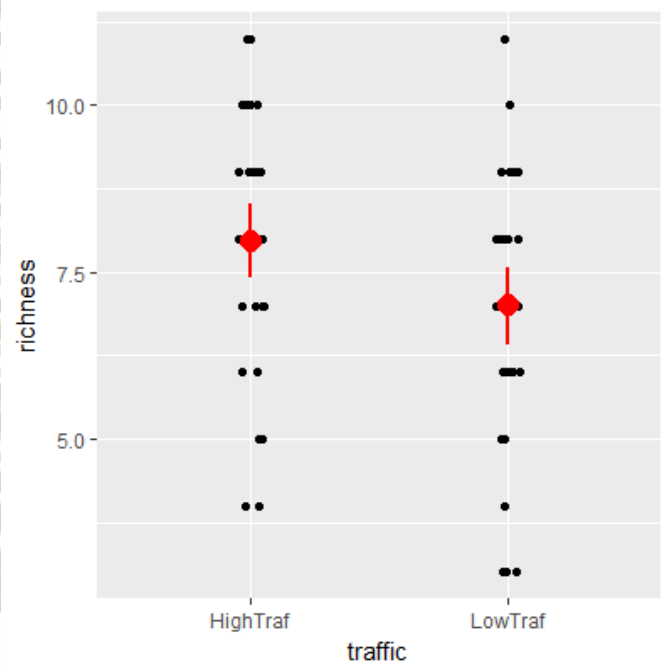
Data analyses

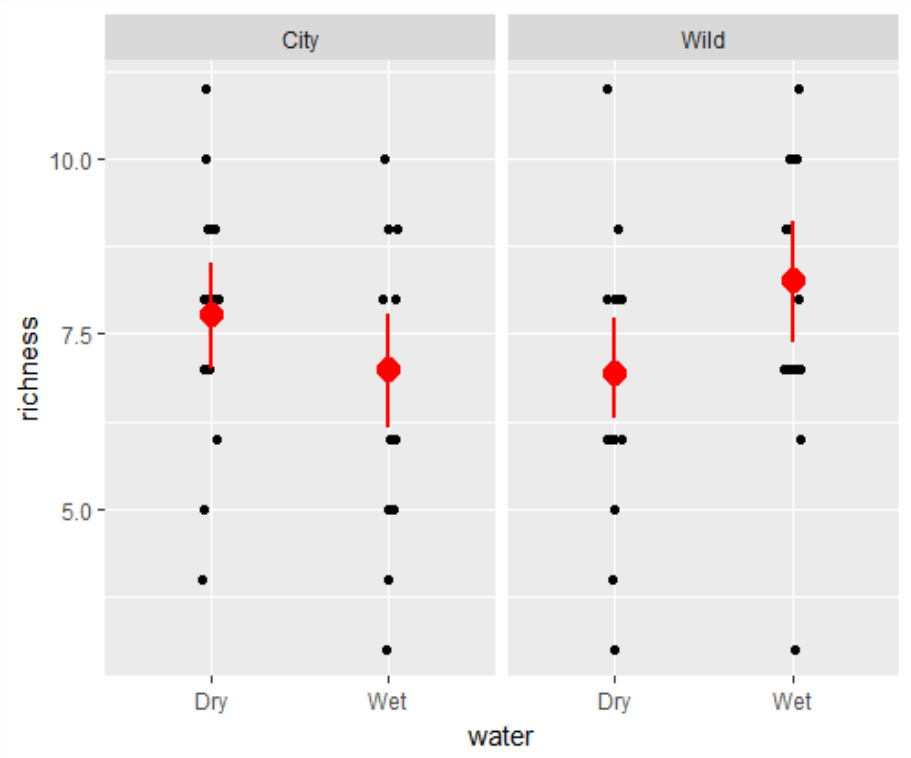
- 3 sets of analyses
  1. Univariate analyses of richness, abundance, and Shannon diversity considering overall urban bird communities
  2. Univariate analyses of bird abundance within each of 22 functional groups (including 7 diet groups, 7 foraging strategy groups, 3 urban preference groups, and 5 nesting groups)
  3. NMS analyses of urban bird species composition and functional group composition (considers the individual abundances of all species or functional groups simultaneously)

Data analyses

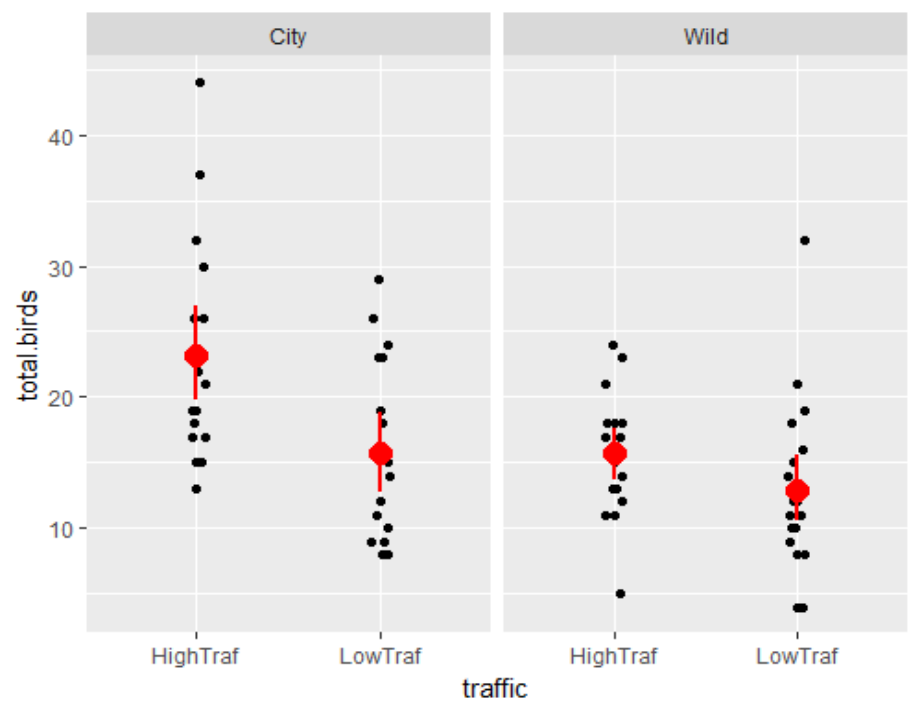
- For all analyses
  - Began with a **saturated model** (days, city, 6 continuous land cover factors, 3 categorical habitat designations + all categorical interactions)
  - Simplified these models using **stepwise parameter selection** process based on model **AIC values** (‘drop1’ or ‘step’ function in R)
  - Validated reduced models by examining **variance inflation factor** (VIF; ‘vif’ function in R), and ensuring no factors had VIF values >10
  - Evaluated reduced models using either **ANCOVA** or **CCA with PerMANCOVA** using Type III (marginal) sums of squares (parameter order does not matter)
  - Performed post-hoc tests to compare individual treatment combinations for significant interactions (e.g., City+Wet vs. City+Dry vs. Wild+Wet vs. Wild+Dry)

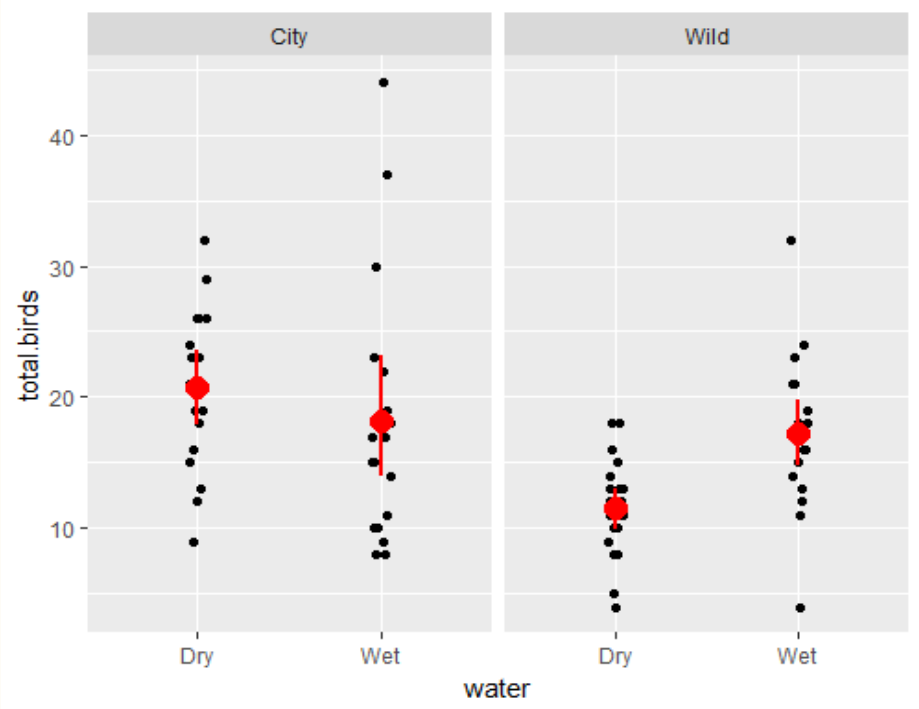






- Bird species richness was higher in habitats with permanent bodies of water than in those without permanent water (ANCOVA, $P < 0.0001$).

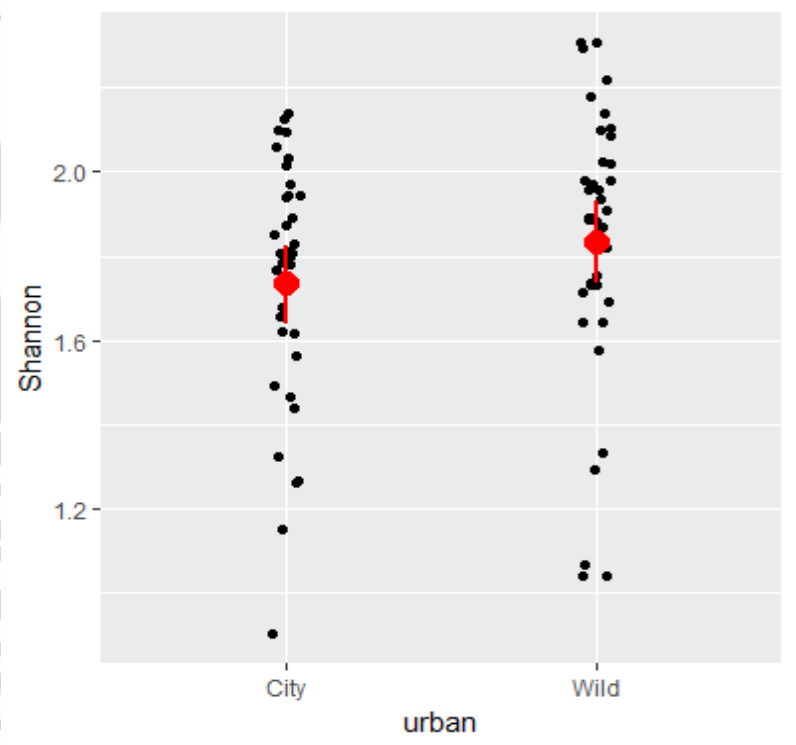


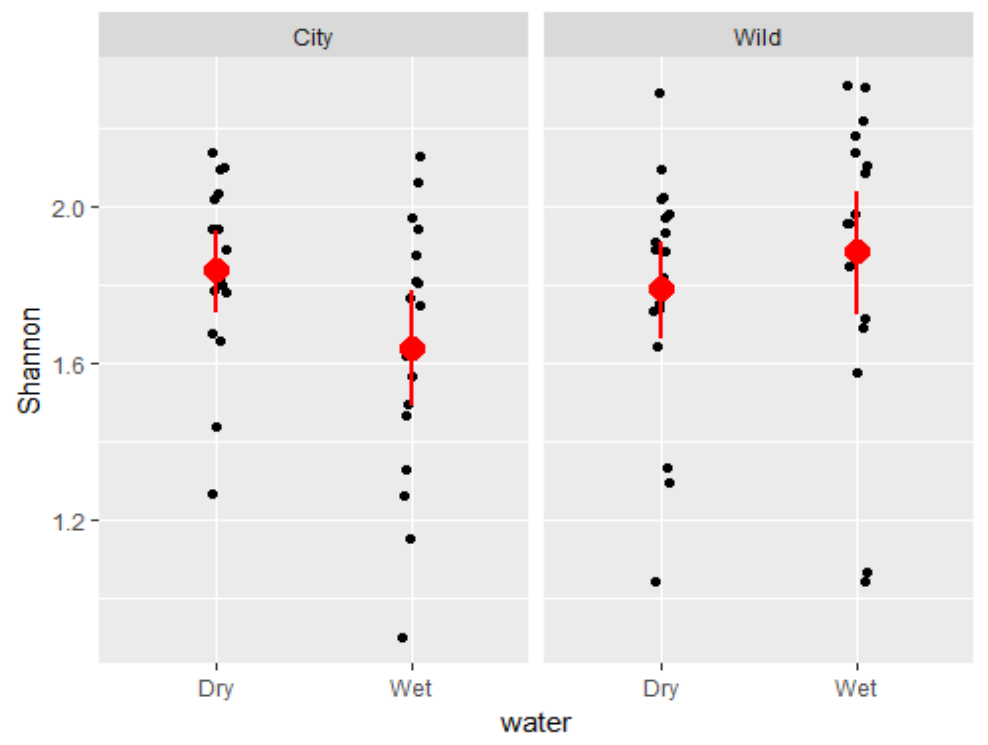


- Bird abundance was higher in habitats where human abundance and frequency of human presence were relatively high.

- Urban bird abundance was influenced by the interaction between habitat urbanity and presence of water (ANCOVA, P = 0.0051).

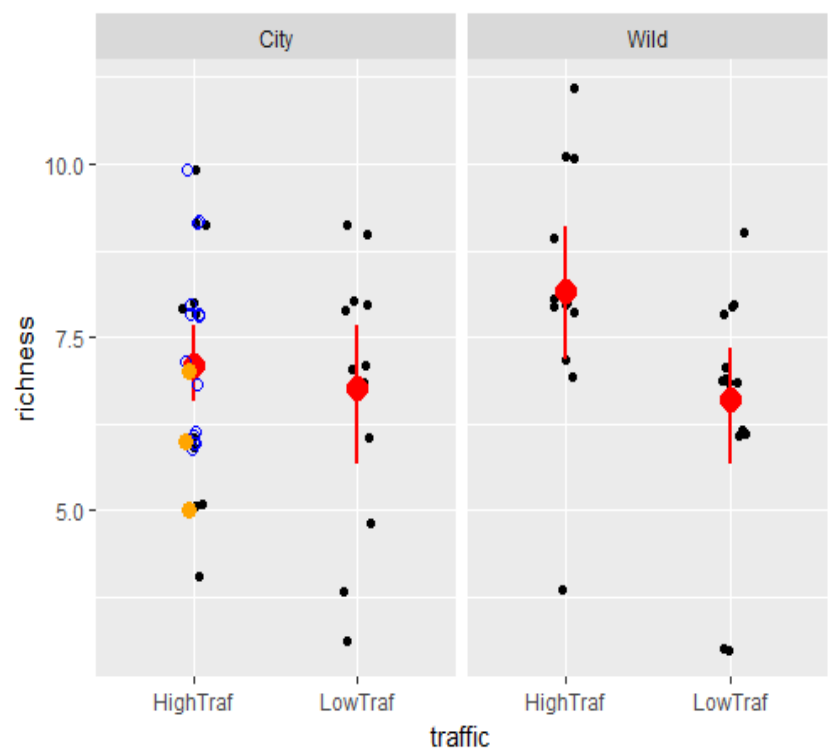
P: p-value, denoting statistical significance (*, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$).

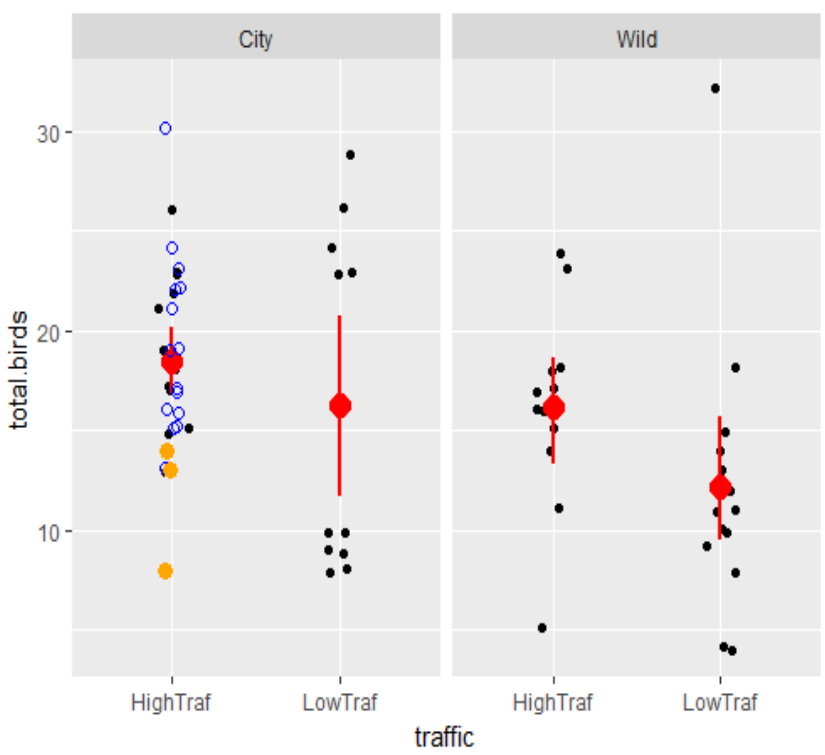


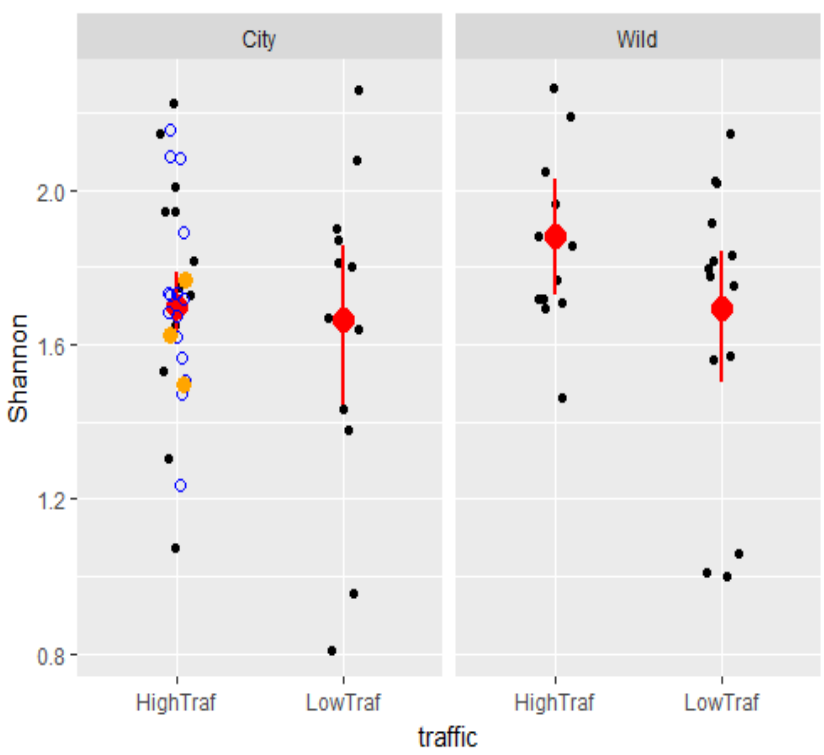


- Urban bird diversity was higher in “wild” urban habitats

- Among urban habitats with permanent bodies of water present, bird diversity was higher in wilder urban habitats





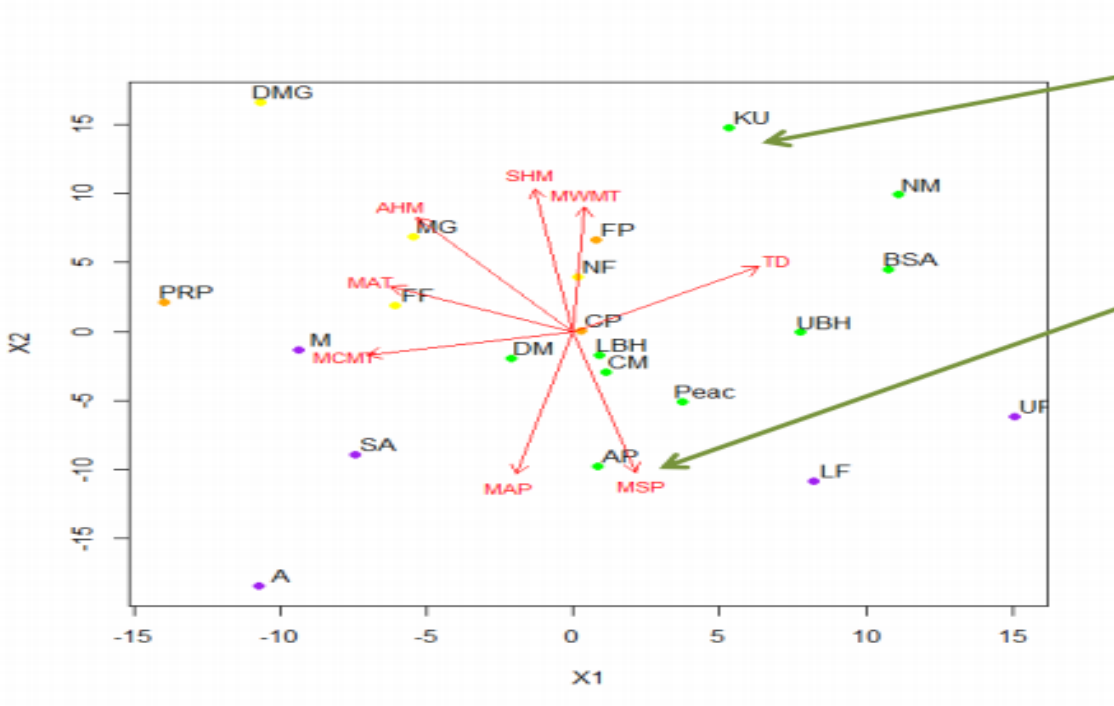


How do community gardens compare to all other sites surveyed?

- Orange circles are UTRGV research garden

Position of data in a multidimensional space

NMDS - Biplot

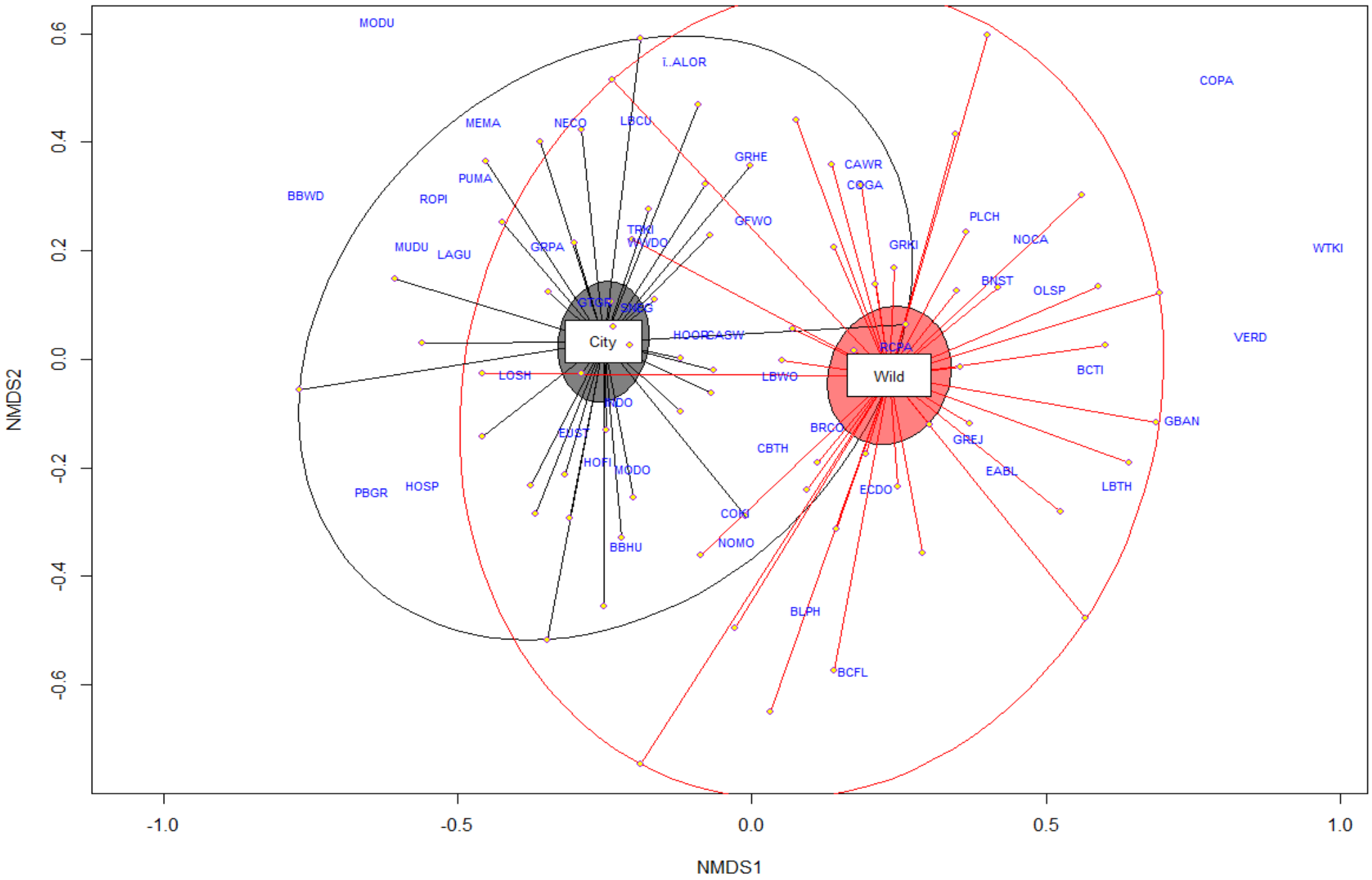


Data points considering scores in 2D

Direction of the arrows +/- indicate the trend of points (towards the arrow indicates more of the variable)

The closeness of points will indicate how similar they are

It is up to you to determine where groupings should be made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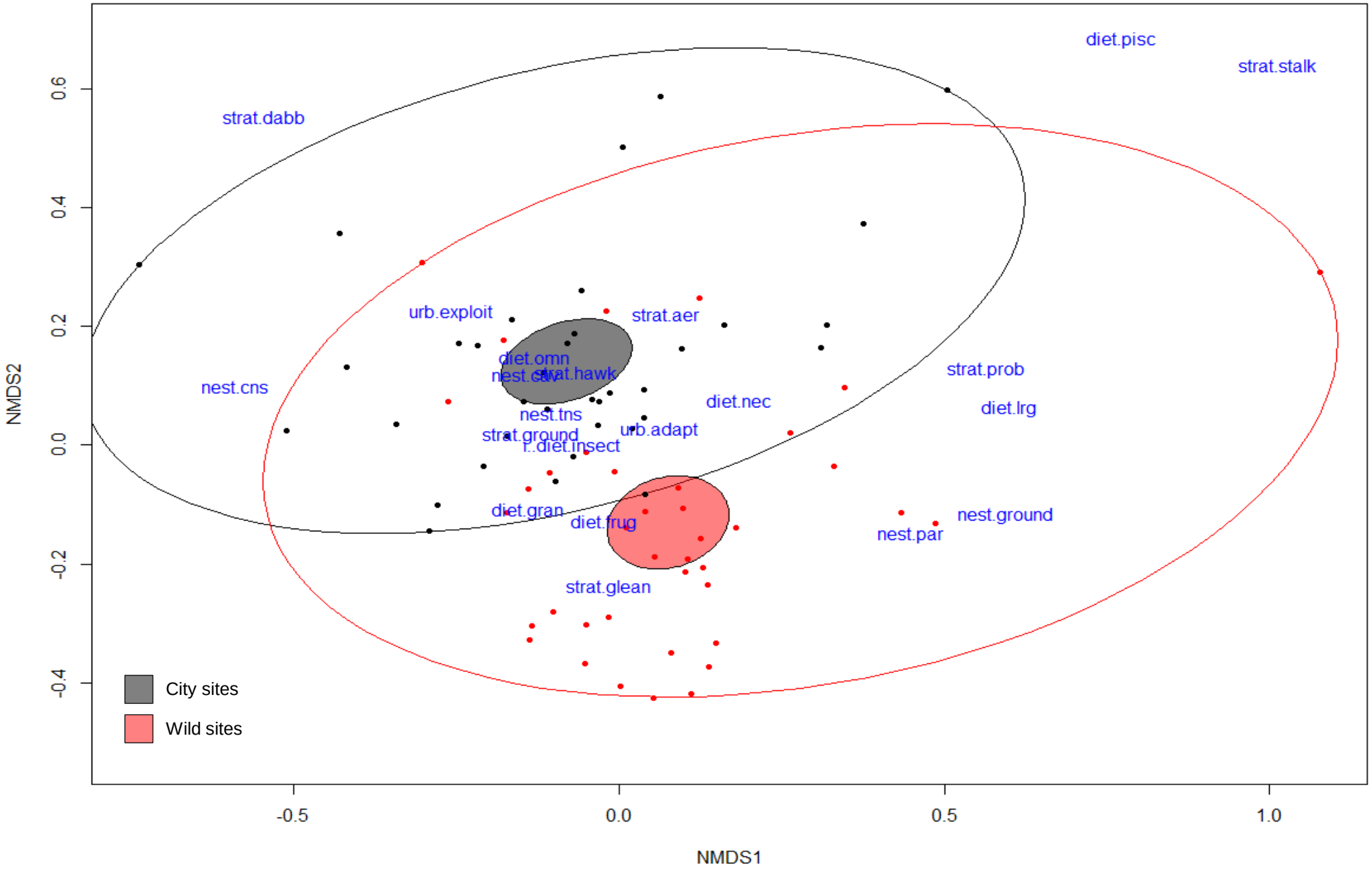
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diet.nec
diet.lrg
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City sites
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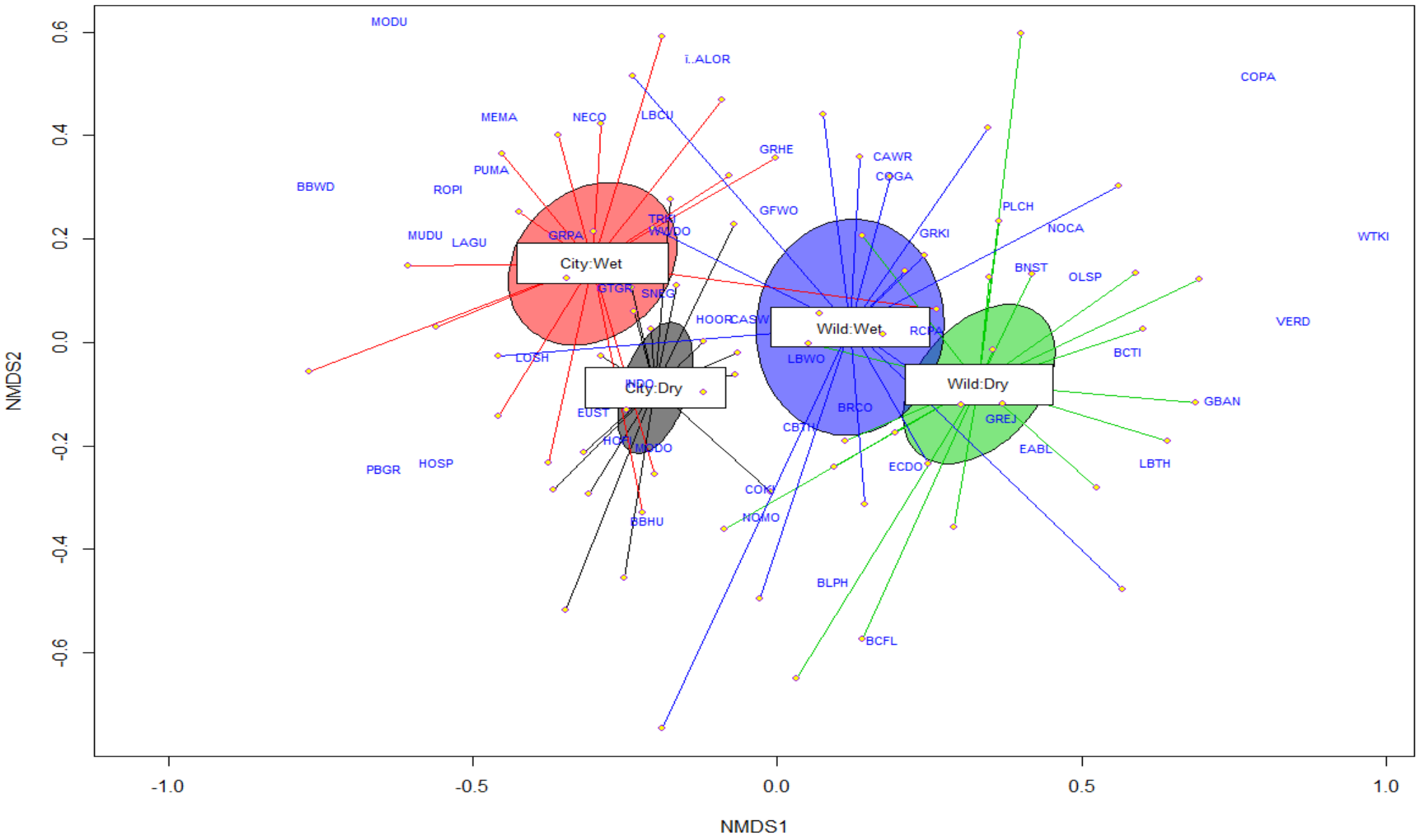
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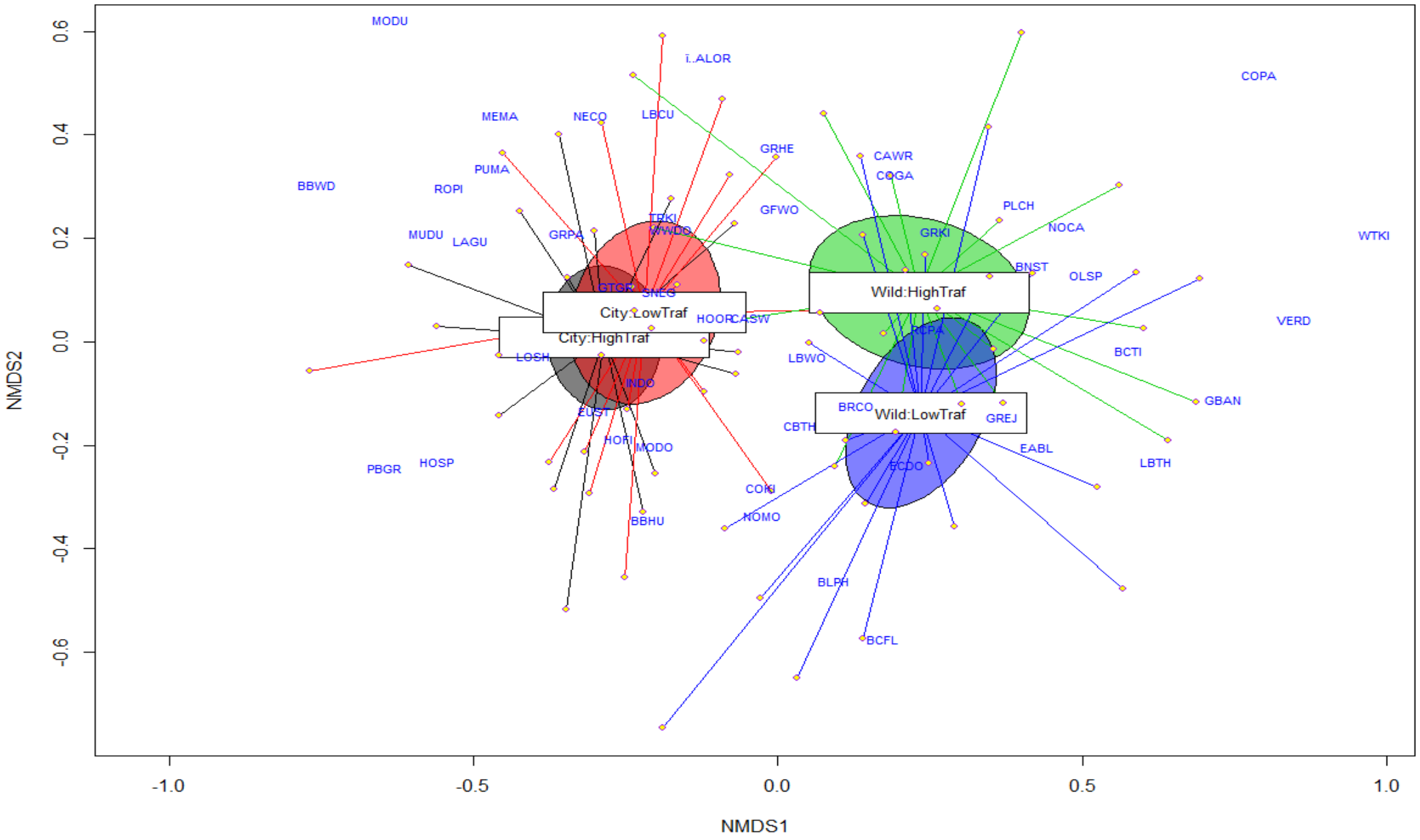
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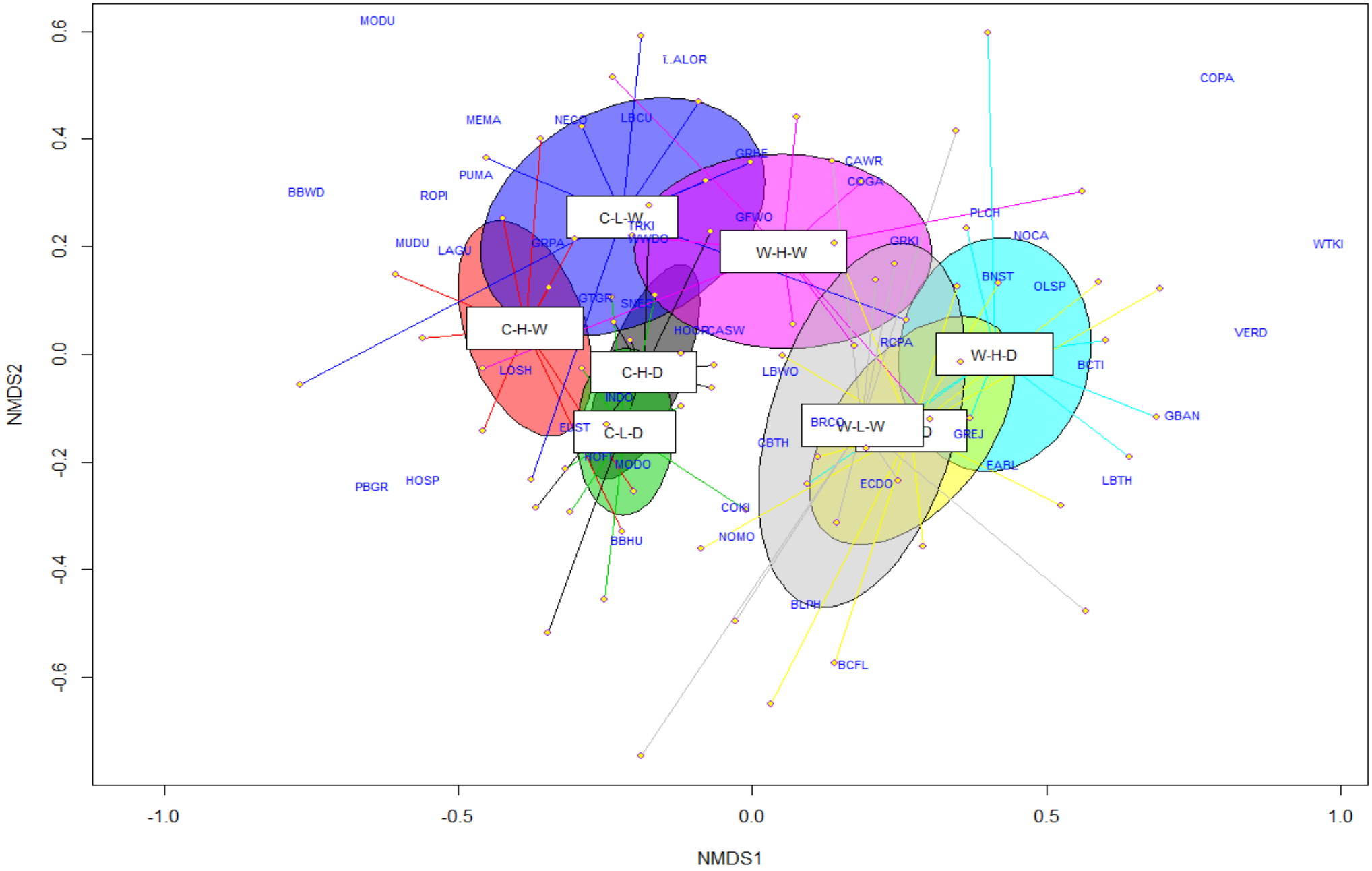
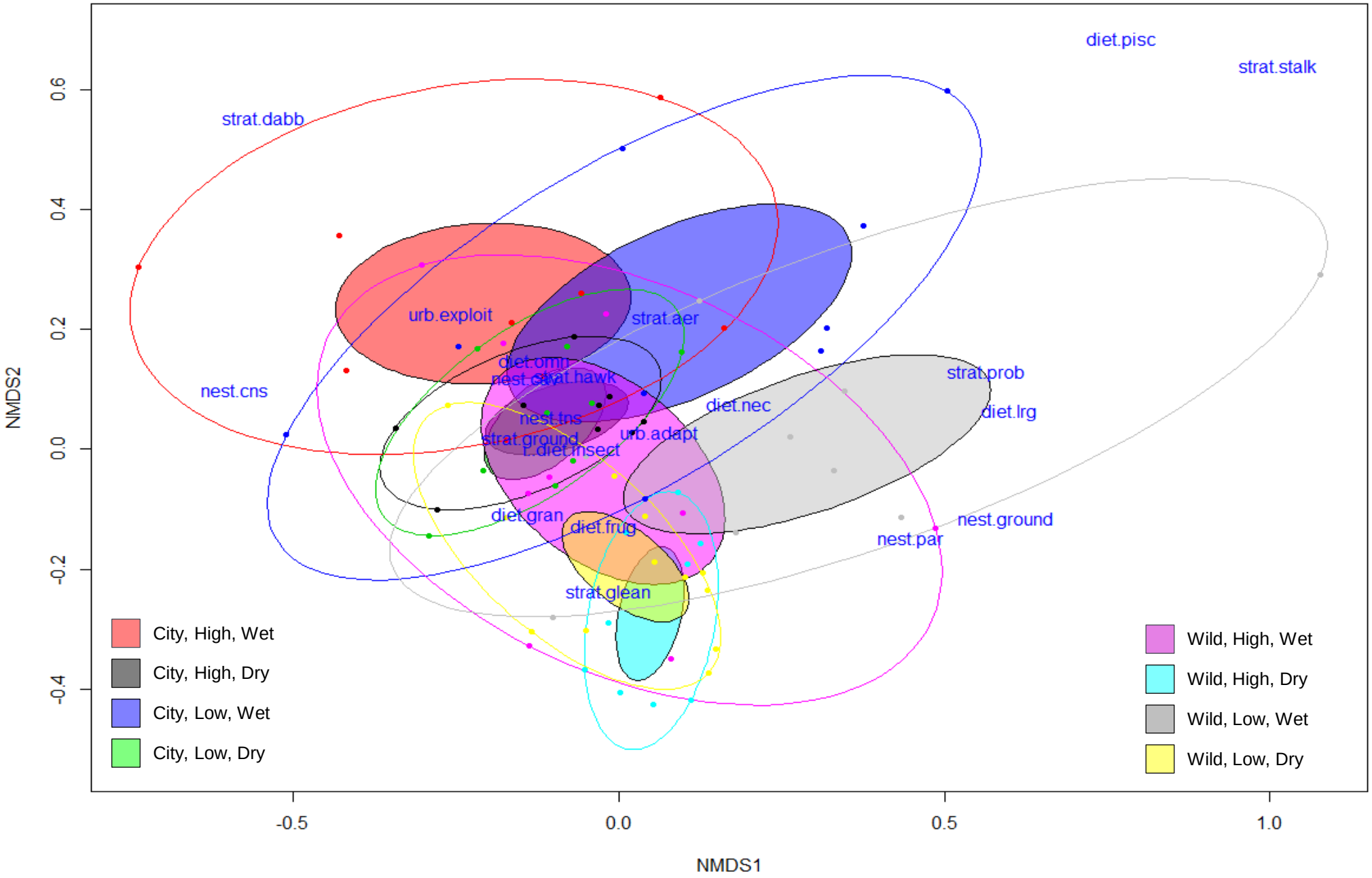
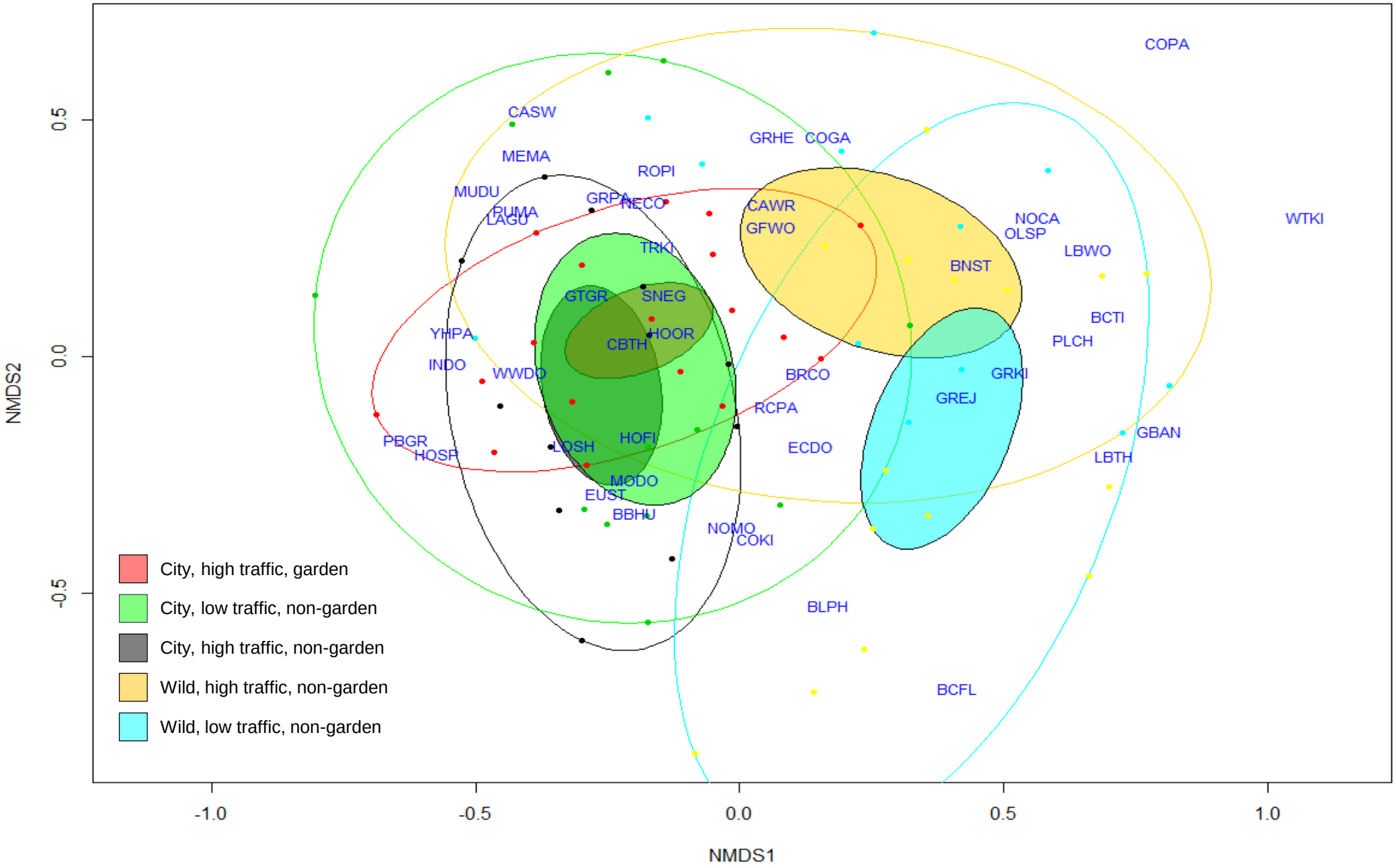
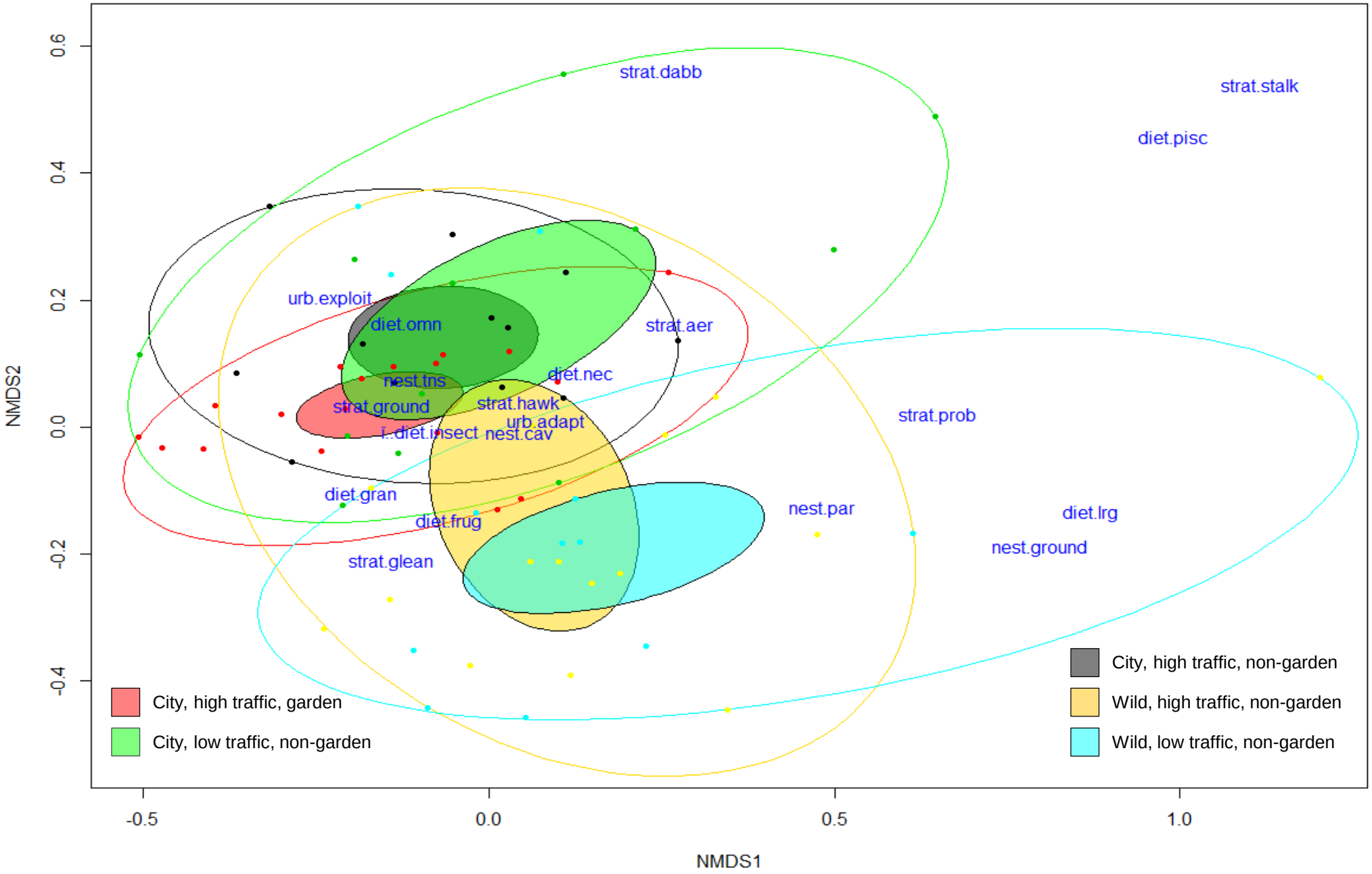
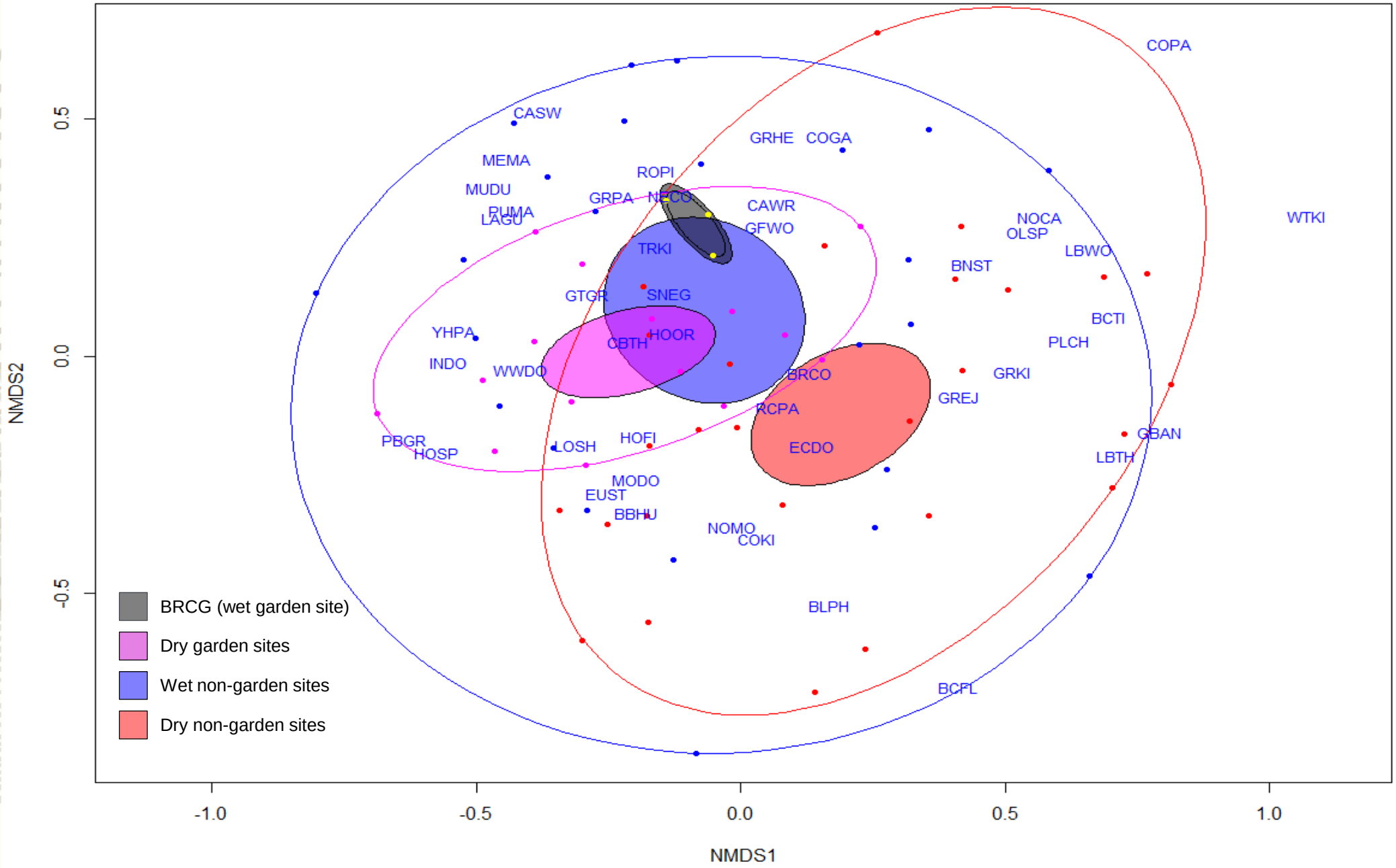
0.5
1.0


MODU
LALOR
COPA
MEMA
NECO
LBCU
GRBE
CAWR
PUMA
COGA
BBWD
ROPI
C-L-W
TRKI
GFWO
PLCH
MUDU
LAGU
GRPA
WWDO
W-H-W
GRKI
NOCA
WTKI
BNST
OLSP
GTGR
SNEG
C-H-W
HOOPCASW
RCPA
VERD
W-H-D
LOSH
C-H-D
LBWO
BCTI
INDO
BRCO
W-L-W
GBAN
EUST
C-L-D
GREJ
CBTH
HOPR
MODO
EABL
LBTH
PBGR
HOSP
ECDO
COKI
NOMO
BBHU
BLRH
BCFL
NMDS2
NMDS1
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-1.0
-0.5
0.0
0.5
1.0


diet.pisc
strat.stalk
strat.dabb
urb.exploit
strat.aer
diet.omn
nest.cavity
strat.hawk
nest.cns
strat.prob
diet.nec
diet.lrg
nest.tns
urb.adapt
strat.ground
t.diet.insect
diet.gran
diet.frug
nest.ground
nest.par
strat.glean
City, High, Wet
City, High, Dry
City, Low, Wet
City, Low, Dry
Wild, High, Wet
Wild, High, Dry
Wild, Low, Wet
Wild, Low, Dry
NMDS2
NMDS1
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.5
0.0
0.5
1.0


COPA
CASW
GRHE
COGA
MEMA
ROPI
MUDU
GRPA
NECO
CAWR
PUMA
LAGU
GFWO
NOCA
OLSP
WTKI
TRKI
LBWO
BNST
GTGR
SNEG
BCTI
YHPA
HOOR
CBTH
PLCH
INDO
WWDO
BRCO
GRKI
GREJ
RCPA
PBGR
HOFI
GBAN
HOSP
LOSH
ECDO
LBTH
MODO
EUST
BBHU
NOMO
COKI
BLPH
BCFL
City, high traffic, garden
City, low traffic, non-garden
City, high traffic, non-garden
Wild, high traffic, non-garden
Wild, low traffic, non-garden
NMDS2
0.5
0.0
-0.5
-1.0
-0.5
0.0
0.5
1.0
NMDS1


strat.dabb
strat.stalk
diet.pisc
urb.exploit
diet.omn
strat.aer
diet.nec
nest.tns
strat.ground
strat.hawk
urb.adapt
i..diet.insect
nest.cav
strat.prob
diet.gran
diet.frug
nest.par
diet.lrg
nest.ground
strat.glean
City, high traffic, garden
City, low traffic, non-garden
City, high traffic, non-garden
Wild, high traffic, non-garden
Wild, low traffic, non-garden
NMDS2
NMDS1
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.5
0.0
0.5
1.0


COPA
WTKI
CASW
GRHE
COGA
MEMA
ROPI
MUDU
GRPA
NECO
CAWR
PUMA
LAGU
GFWO
NOCA
OLSP
LBWO
TRKI
BNST
GTGR
SNEG
BCTI
YHPA
HOOR
CBTH
PLCH
INDO
WWDO
BRCO
GRKI
GREJ
RCPA
PBGR
HOSP
LOSH
HOFI
ECDO
GBAN
LBTH
MODO
EUST
BBHU
NOMO
COKI
BLPH
BCFL
BRCG (wet garden site)
Dry garden sites
Wet non-garden sites
Dry non-garden sites
NMDS2
NMDS1
0.5
0.0
-0.5
-1.0
-0.5
0.0
0.5
1.0

ANCOVA results for overall bird species richness

Parameter	Estimate	d.f.	SS	RSS	AIC	F_{67}	P	
Paved cover	-0.0547	1	10.59	178.84	79.18	4.21	**0.0440**	*
Building cover	-0.1565	1	27.36	195.62	85.90	10.89	**0.0015**	**
Woody cover	0.0447	1	14.65	182.91	80.86	5.83	**0.0185**	*
Urbanity	2.0235	1	36.66	204.92	89.38	14.60	**0.0003**	***
Traffic	0.4777	1	16.04	184.29	81.43	6.39	**0.0139**	*
Water	0.2477	1	2.58	170.84	75.75	1.03	0.3141	
Urbanity*Water	1.1946	1	59.93	228.19	97.45	23.86	**<0.0001**	***
Model		*7*		*168.26*	*76.60*	*5.15*	***0.0001***	***

ANCOVA results for total bird abundance

Parameter	Estimate	d.f.	SS	RSS	AIC	F_{67}	P	
City	-1.4223	1	131.55	2628.20	280.74	3.53	0.0646	.
Urbanity	2.4936	1	462.38	2959.10	289.64	12.41	**0.0008**	***
Traffic	2.4381	1	442.01	2938.70	289.12	11.86	**0.0010**	***
Water	-0.7436	1	41.12	2537.80	278.12	1.10	0.2973	
Urban*Traffic	1.2564	1	117.38	2614.10	280.34	3.15	0.0805	.
Urban*Water	2.0492	1	312.25	2808.90	285.73	8.38	**0.0051**	**
Traffic*water	-0.9508	1	67.23	2563.90	278.89	1.80	0.1837	
Model		*7*		*2496.70*	*278.89*	*6.31*	***<0.0001***	***

ANCOVA results for overall Shannon diversity index

Parameter	Estimate	d.f.	SS	RSS	AIC	F_{64}	P	
Days	-0.0035	1	0.15	4.90	-184.58	1.96	0.1668	
City	-0.0583	1	0.17	4.92	-184.28	2.22	0.1410	
Mowed cover	-0.0101	1	0.41	5.17	-180.61	5.54	**0.0216**	*
Paved cover	-0.0125	1	0.38	5.14	-181.10	5.09	**0.0275**	*
Building cover	-0.0273	1	0.58	5.34	-178.19	7.82	**0.0068**	**
Woody cover	0.0068	1	0.33	5.08	-181.85	4.40	**0.0398**	*
Urbanity	0.4407	1	0.79	5.54	-175.36	10.59	**0.0018**	**
Traffic	0.0418	1	0.12	4.88	-184.94	1.65	0.2042	
Water	0.1322	1	0.46	5.22	-179.90	6.21	**0.0153**	*
Urbanity*Water	0.2260	1	1.36	6.12	-167.98	18.30	**<0.0001**	***
Model		*10*		*4.76*	*-184.84*	*3.38*	***0.0014***	***

Potential Impacts of Study

- Community garden
  - Growing practices
  - Landscaping around garden
  - Pest management practices
- Wildlife management
  - Management of birds, and maybe bats, in urban areas
- Policy
  - What areas need to be protected?
  - What spaces can be utilized and their potential benefits?

Questions?

Thank you