Drought and Time Modify Land-Use Effects on Bird Community Structure in an Urban Desert Ecosystem

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Introduction:

CAP LTER teams have collected data on land-use and bird sightings on 45 sites across the Greater Phoenix Area over the last 15 years. **Land-use effects** and **drought** influence **bird abundance** and community **species richness** variation over time across these sites was investigated.

Methods:

- Point count surveys conducted each quarter of each year (January, April, July and October) since 2000
- Land uses categorized into different habitats: ***Agriculture***, ***Desert***, and ***Urban*** sites separated by 3 landscaping types: ***Mesic***; ***Xeric***, and ***Mesic/Xeric mix.***

Analysis Methods:

- Bird dataset included data from Quarter 1 (2001) through Quarter 2 (2014), 28 quarterly samples from 45 sites, with some missing samples throughout
- General Linear Mixed Models used to investigate: **1)** how land-use effects influenced bird abundance and richness over time, and **2)** how present and previous drought conditions (as measured using **Palmer's Drought Severity Index, PDSI**) and time influence land use effect sizes, and bird abundance and richness in each land use type

Results:

1. Results showed **a significant land-use by time interaction** on both species richness and abundance, indicating that land-use effects were not consistent over time (Figure 1).
2. GLMMs showed significant main effects of land-use and survey, and a significant land-use X survey interaction, for both bird abundance and richness (all effects $p < 0.005$).

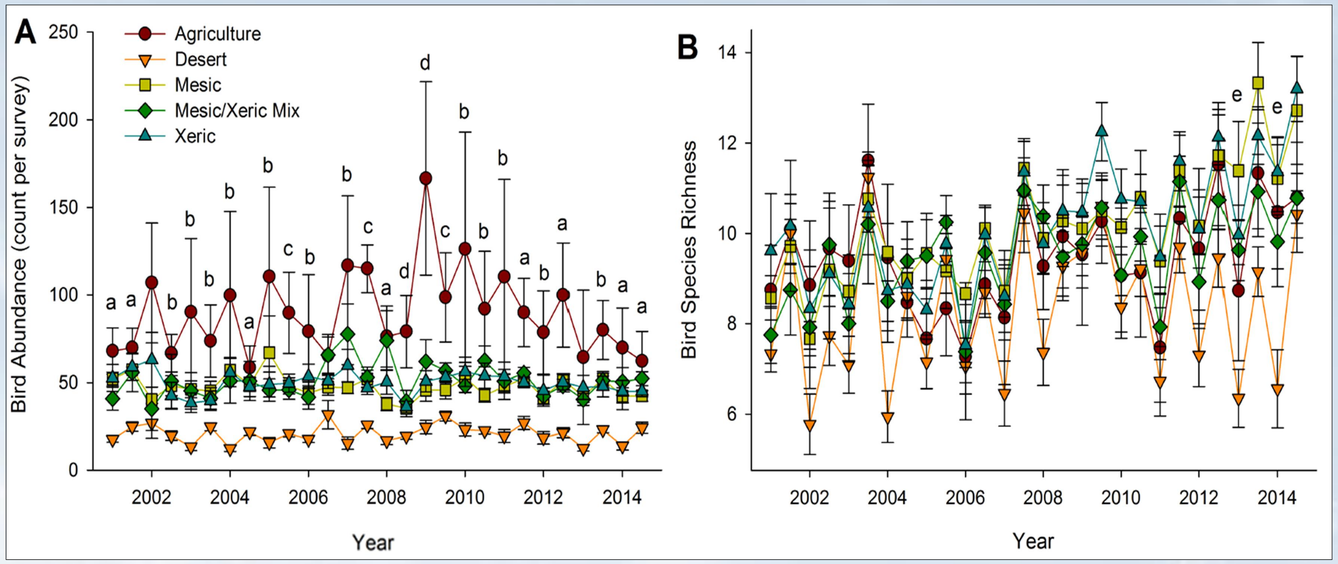

Figure 1. Bird abundance (A) and species richness (B) for each land-use type over time (total number collected per sampling event). In A and B, letters denote results of a priori planned contrasts: a, years with significant agriculture-desert and desert-urban contrasts; b, years with significant agriculture-desert contrast only; c, years with significant agriculture-desert, agriculture-urban, and desert-urban contrasts; d, years with significant agriculture-desert and agriculture-urban contrasts; and e, year with significant desert-urban contrast only ("urban" = equally weighted mesic, mesic/xeric mixed, and xeric land uses).

Variables in Model	Δ_i	w_i	R^2
Bird Abundance			
PDSI 4 Qs prior (-0.047)	0.00	0.13	0.15
PDSI prior Q (-0.025), PDSI 4 Qs prior (-0.047)	0.64	0.09	0.17
PDSI current Q (-0.039), PDSI prior Q (0.062), PDSI 4 Qs prior (-0.060)	0.78	0.09	0.21
PDSI 2 Qs prior (-0.018), PDSI 4 Qs prior (-0.057)	1.65	0.06	0.15
Bird Species Richness			
PDSI current Q (0.025), PDSI prior Q (-0.030), Time (0.017)	0.00	0.13	0.33
Time (0.016)	0.11	0.12	0.25
PDSI current Q (0.033), PDSI prior Q (-0.037), PDSI 4 Qs prior (0.010), Time (0.018)	0.76	0.09	0.35
PDSI current Q (0.035), PDSI prior Q (-0.040), PDSI 3 Qs prior (0.011), Time (0.018)	0.77	0.09	0.35
PDSI current Q (0.007), Time (0.017)	1.49	0.06	0.26
PDSI 2 Qs prior (-0.009), Time (0.016)	1.54	0.06	0.26
PDSI prior Q (-0.007), Time (0.015)	1.69	0.06	0.25

Table 1. Best performing GLMMs (wi > 0.05) predicting land-use effect size (Cohen's d) on bird and ground-dwelling arthropod abundance and richness for each survey.

Table 2. Best performing GLMMs (wi > 0.05) predicting mean bird abundance for each survey within land-use types.

Variables in Model	Δ_i	w_i	R^2
Agriculture			
PDSI 4 Qs prior (-0.010)	0.00	0.07	0.01
Time (0.004)	0.09	0.07	0.00
PDSI current Q (0.006)	0.15	0.07	0.00
PDSI prior Q (-0.005)	0.19	0.07	0.00
PDSI 2 Qs prior (-0.001)	0.23	0.06	0.00
PDSI 3 Qs prior (0.001)	0.23	0.06	0.00
Desert			
PDSI 3 Qs prior (0.044)	0.00	0.15	0.10
PDSI prior Q (-0.010), PDSI 3 Qs prior (0.044)	1.75	0.06	0.10
PDSI current Q (0.005), PDSI 3 Qs prior (0.044)	1.91	0.06	0.10
PDSI 2 Qs prior (0.004), PDSI 3 Qs prior (0.041)	1.97	0.06	0.10
PDSI 3 Qs prior (0.044), Time (0.001)	1.98	0.06	0.09
PDSI current Q (0.035), PDSI prior Q (-0.044), PDSI 3 Qs prior (0.058)	2.16	0.05	0.11
PDSI 4 Qs prior (0.036)	2.24	0.05	0.07
Mesic			
PDSI current Q (0.022)	0.00	0.12	0.14
PDSI current Q (0.022), Time (-0.006)	0.85	0.08	0.16
PDSI current Q (0.025), PDSI 3 Qs prior (0.008)	1.47	0.06	0.15
PDSI current Q (0.023), PDSI 2 Qs prior (0.007)	1.70	0.05	0.14
PDSI current Q (0.029), PDSI prior Q (-0.011)	1.71	0.05	0.14
Xeric/Mesic Mix			
Time (0.008)	0.00	0.08	0.03
PDSI prior Q (-0.016)	0.19	0.07	0.02
PDSI current Q (-0.009)	0.55	0.06	0.01
PDSI 3 Qs prior (-0.003)	0.80	0.05	0.00
PDSI 2 Qs prior (0.003)	0.82	0.05	0.00
PDSI 4 Qs prior (0.000)	0.84	0.05	0.00
Xeric			
PDSI 2 Qs prior (0.034)	0.00	0.13	0.19
PDSI current Q (0.009), PDSI 2 Qs prior (0.034)	0.98	0.08	0.21
PDSI current Q (0.017), PDSI 3 Qs prior (0.027)	1.66	0.06	0.19
PDSI 2 Qs prior (0.034), Time (-0.002)	1.86	0.05	0.19
PDSI prior Q (0.004), PDSI 2 Qs prior (0.032)	1.91	0.05	0.19
PDSI 2 Qs prior (0.036), PDSI 2 Qs prior (-0.003)	1.97	0.05	0.19

Table 3. Best performing GLMMs (wi > 0.05) predicting mean bird species richness for each survey within land-use types.

Variables in Model	Δ_i	w_i	R^2
Agriculture			
PDSI current Q (-0.252), PDSI 3 Qs prior (-0.276)	0.00	0.24	0.28
PDSI current Q (-0.248), PDSI 4 Qs prior (-0.271)	0.07	0.23	0.28
PDSI current Q (-0.253), PDSI prior Q (0.006), PDSI 4 Qs prior (-0.273)	1.64	0.11	0.28
PDSI current Q (-0.313), PDSI prior Q (0.090), PDSI 3 Qs prior (-0.302)	1.70	0.10	0.29
Desert			
PDSI current Q (0.129), PDSI prior Q (-0.100)	0.00	0.11	0.01
PDSI current Q (0.147), PDSI prior Q (-0.091), Time (0.050)	1.43	0.05	0.02
PDSI 2 Qs prior (-0.021)	1.48	0.05	0.00
Mesic			
PDSI 4 Qs prior (-0.129), Time (0.224)	0.00	0.18	0.50
PDSI prior Q (-0.067), PDSI 4 Qs prior (-0.131), Time (0.217)	0.92	0.11	0.50
PDSI 3 Qs prior (-0.118), Time (0.229)	1.24	0.10	0.49
PDSI current Q (-0.044), PDSI 4 Qs prior (-0.144), Time (0.217)	1.35	0.09	0.50
PDSI prior Q (-0.119), PDSI 2 Qs prior (0.109), PDSI 4 Qs prior (-0.188), Time (0.212)	1.92	0.07	0.50
PDSI 2 Qs prior (0.007), PDSI 4 Qs prior (-0.133), Time (0.224)	1.99	0.07	0.50
Xeric/Mesic Mix			
PDSI 3 Qs prior (-0.119), Time (0.119)	0.00	0.13	0.20
PDSI 2 Qs prior (-0.137), Time (0.118)	0.48	0.10	0.19
PDSI current Q (0.170), PDSI prior Q (-0.224), Time (0.126)	0.88	0.08	0.19
PDSI prior Q (-0.062), PDSI 3 Qs prior (-0.110), Time (0.113)	1.14	0.07	0.20
PDSI 4 Qs prior (-0.089), Time (0.117)	1.58	0.06	0.18
PDSI 2 Qs prior (-0.063), PDSI 3 Qs prior (-0.074), Time (0.118)	1.66	0.06	0.20
PDSI current Q (0.113), PDSI prior Q (-0.167), PDSI 3 Qs prior (-0.066), Time (0.121)	1.74	0.05	0.20
Xeric			
PDSI 4 Qs prior (-0.139), Time (0.209)	0.00	0.21	0.37
PDSI 3 Qs prior (-0.119), Time (0.214)	1.52	0.10	0.36
PDSI current Q (-0.034), PDSI 3 Qs prior (-0.150), Time (0.203)	1.72	0.09	0.37
PDSI 2 Qs prior (0.049), PDSI 4 Qs prior (-0.164), Time (0.209)	1.77	0.09	0.37
PDSI prior Q (-0.020), PDSI 4 Qs prior (-0.139), Time (0.207)	1.93	0.08	0.36

Results (cont'd):

3. The magnitude of land use effect sizes on bird abundance were predicted to the occurrence of droughts (as measured by PDSI), with **effect sizes being largest during dry periods one year prior to and during the survey** (Table 1).
4. Land use effect sizes on bird species richness were also influenced by droughts, with **larger effects during dry periods one year prior to and wet periods during the survey**
5. However land use effect sizes on bird species richness also increased over time. In fact, a priori planned contrasts indicated that **significant differences between land uses were not observed until 2013 and 2014.**

Conclusions:

1. Variation effects of land use on bird abundance and species richness were **related to time-lag and current effects of drought** (Tables 2-3), and land effect use effect size on species richness also is **growing** over time.
2. Future work on this project will investigate the long-term effects of land use on beta diversity patterns, community structure, and functional trait diversity of bird communities.

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