Linking nest microhabitat selection to nest survival within declining pheasant populations in the Central Valley of California

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Appendix S1. Nest habitat variables shown to have evidenced growth rates during the study period and required adjustment to prevent plant phenology from confounding differences between successful and failed nests. The slope coefficient estimated from each linear mixed effect model was used to adjust cover and height variables to a peak nesting date specific to each year. 95% CI = 95 percent confidence interval.

Year	Peak nesting date	Variable	Estimate	95% CI Lower	95% CI Upper
2014	25 April	% Perennial grass 0 ha	-0.255	-0.479	-0.032
		% Perennial grass 0.03 ha	-0.286	-0.481	-0.091
		% Perennial grass 0.2 ha	-0.278	-0.452	-0.103
		% Perennial forb 0 ha	0.159	0.012	0.306
		% Residual cover 0 ha	-0.315	-0.570	-0.059
		% Residual cover 0.03 ha	-0.248	-0.462	-0.033
		% Residual cover 0.2 ha	-0.236	-0.439	-0.033
		Perennial grass height 0 ha	-0.362	-0.533	-0.190
		Perennial grass height 0.03 ha	-0.279	-0.435	-0.123
		Perennial grass height 0.2 ha	-0.269	-0.417	-0.121
		Perennial forb height 0.03 ha	0.246	0.098	0.395
		Perennial forb height 0.2 ha	0.232	0.098	0.365
		Annual grass height 0 ha	0.193	0.069	0.317
		Annual grass height 0.03 ha	0.125	0.016	0.233
		Annual grass height 0.2 ha	0.150	0.049	0.250
2015	28 April	% Residual cover 0 ha	-0.239	-0.463	-0.016
		% Residual cover 0.03 ha	-0.175	-0.335	-0.015
		Annual grass height 0 ha	-0.248	-0.480	-0.016
		Annual grass height 0.03 ha	-0.216	-0.391	-0.042
		Annual grass height 0.2 ha	-0.234	-0.399	-0.069
		Residual cover height 0.03 ha	-0.246	-0.440	-0.052
		Residual cover height 0.2 ha	-0.253	-0.434	-0.072
2016	28 April	% Residual cover 0.03 ha	0.152	0.003	0.304
		% Residual cover 0.2 ha	0.179	0.040	0.318
2017	25 April	% Annual grass 0 ha	-0.312	-0.570	-0.054
		% Annual grass 0.03 ha	-0.291	-0.500	-0.081
		% Annual grass 0.2 ha	-0.301	-0.495	-0.106
		% Residual cover 0 ha	-0.216	-0.372	-0.060
		% Residual cover 0.03 ha	-0.143	-0.265	-0.020
		% Residual cover 0.2 ha	-0.165	-0.280	-0.050
		Annual grass height 0 ha	-0.240	-0.447	-0.033
		Annual grass height 0.03 ha	-0.255	-0.470	-0.039
		Annual grass height 0.2 ha	-0.299	-0.491	-0.108

Appendix S2. Comparison of models used in restricted data sets. Models ≥ 2 AIC$_c$ units relative to the null model were considered to be significant at contributing to probabilities of nest-site selection, but correlated variables (R ≥ 0.65) were dropped in subsequent steps. -2 LL = deviance; K = number of parameters; AIC$_c$ = Akaike's Information Criterion with second order bias correction; ΔAIC$_c$ = difference between model of interest and most explanatory model with second-order bias correction; w = model probability.

Year[a]	Model[b]	-2LL	K	AIC$_c$	ΔAIC$_c$	w
2014	(Q)Vertical cover (%)	99.6	4	107.9	0.00	0.99
	Vertical cover (%)	117.0	3	123.3	15.3	0.99
	(Q)Horizontal cover (%)	117.9	4	126.3	18.3	1.00
	Horizontal cover (%)	122.8	3	129.0	21.1	1.00
	Intercept-Only	151.1	2	155.2	47.3	1.00
2015-2017	Vertical cover (%)	286.8	4	295.0	0.00	0.65
	(Q)Vertical cover (%)	286.4	5	296.7	1.70	0.28
	Robel pole height (cm)	292.8	4	301.0	5.96	0.03
	(Q)Robel pole height (cm)	291.6	5	301.8	6.84	0.02
	Intercept-Only	296.6	3	302.8	7.75	0.01

[a]The horizontal cover metric was only used in 2014 and was replaced by the Robel pole height measurement during 2015-17.

[b](Q) indicates that both the first order and quadratic term were included in the model.

Appendix S3. Importance rankings (*d*AIC) and beta results (β) for microhabitat variables evaluated using preliminary variable reduction analyses for ring-necked pheasant nest habitat selection in the Central Valley, CA, USA, 2013 – 2017.

Microhabitat variable	*d*AIC	β
% Vertical cover	29.1	0.69
% Bare ground 0 ha	16.4	-0.57
% Bare ground 0.03 ha	15.8	-0.58
% Bare ground 0.2 ha	14.5	-0.48
% Residual cover 0.03 ha	10.7	0.44
% Residual cover 0.2 ha	9.98	0.40
% Residual cover 0 ha	7.23	0.37
Perennial grass height 0.2 ha	3.63	0.33
Annual grass height 0.2 ha	3.23	0.26
Perennial grass height 0.03 ha	2.68	0.30
Residual cover height 0.2 ha	2.48	0.20
% Perennial grass 0.03 ha	2.33	0.17
Annual grass height 0.03 ha	1.05	0.21
% Perennial grass 0 ha	0.62	0.22
% Perennial grass 0.2 ha	0.36	0.08
Perennial forb height 0.2 ha	0.32	0.22
Residual cover height 0.03 ha	0.28	0.13
Residual cover height 0 ha	-0.17	0.11
Perennial forb height 0.03 ha	-0.31	0.04
% Annual forb 0 ha	-0.44	-0.25
Perennial grass height 0 ha	-0.56	0.10
Annual grass height 0 ha	-0.61	0.14
Annual forb height 0 ha	-0.78	-0.11
% Annual forb 0.03 ha	-1.09	-0.11
% Perennial forb 0.2 ha	-1.22	-0.07
% Annual forb 0.2 ha	-1.43	-0.11
Perennial forb height 0 ha	-1.53	0.10
Annual forb height 0.3 ha	-1.67	0.10
Annual forb height 0.03 ha	-1.68	0.03
% Annual grass 0 ha	-1.75	-0.07
Rush height 0.2 ha	-1.79	0.04
% Annual grass 0.2 ha	-1.81	-0.05
% Annual grass 0.03 ha	-1.83	-0.04
% Perennial forb 0.03 ha	-1.86	-0.02
% Perennial forb 0 ha	-1.88	0.10

Appendix S4. Nest-site selection (n = 163), nest survival, and nest survival with ratio of selection models for pheasant nests (n = 160) in the Central Valley, CA, 2014 – 2017. Models $\geq$ 2 AIC$_c$ units relative to the null model were considered to be significant at contributing to probabilities of nest survival, but correlated variables (R $\geq$ 0.65) were dropped in subsequent steps. -2 LL = deviance; K = number of parameters; AIC$_c$ = Akaike's Information Criterion with second order bias correction; ΔAIC$_c$ = difference between model of interest and most explanatory model with second-order bias correction; w = model probability.

Group	Model[a]	Model	-2LL	K	AIC$_c$	ΔAIC$_c$	w
Selection	% Vertical cover (Q)	1	405.6	5	415.8	0.0	0.98
	% Vertical cover	2	415.6	4	423.7	8.0	0.02
	% Residual cover_0 (Q)	3	423.6	5	433.9	18.1	0.00
	% Bare ground_0.2 (Q)	4	425.2	5	435.3	19.6	0.00
	% Bare ground_0	5	427.4	4	435.4	19.7	0.00
	% Bare ground_0.03 (Q)	6	425.4	5	435.6	19.8	0.00
	% Bare ground_0 (Q)	7	425.6	5	435.9	20.1	0.00
	% Bare ground_0.03	8	427.8	4	436.0	20.2	0.00
	% Bare ground_0.2	9	428.8	4	436.9	21.2	0.00
	Residual height_0.2 (Q)	10	428.4	5	438.6	22.9	0.00
	% Residual cover_0.03	11	433.4	4	441.5	25.8	0.00
	% Residual cover_0.2	12	434.6	4	442.7	26.9	0.00
	Residual cover_0.03 (Q)	13	433.4	5	443.6	27.8	0.00
	Residual height_0.03 (Q)	14	433.4	5	443.7	27.9	0.00
	% Residual cover_0.2 (Q)	15	434.0	5	444.1	28.4	0.00
	% Residual cover_0	16	437.0	4	445.0	29.3	0.00
	Perennial grass height_0.03 (Q)	17	439.2	5	449.4	33.6	0.00
	Perennial grass height_0.2	18	441.8	4	449.9	34.2	0.00
	Perennial grass height_0.2 (Q)	19	440.2	5	450.4	34.7	0.00
	Residual height_0.2	20	442.4	4	450.6	34.8	0.00
	Perennial grass height_0.03	21	443.4	4	451.6	35.8	0.00
	% Perennial grass_0.03	22	443.8	4	451.9	36.2	0.00
	% Perennial grass_0.2 (Q)	23	443.0	5	453.2	37.5	0.00

% Perennial grass_0.03 (Q)	24	443.2	5	453.3	37.6	0.00
Annual grass height_0.2	25	445.4	4	453.5	37.7	0.00
Residual height_0.03	26	445.4	4	453.5	37.8	0.00
% Perennial grass_0.2	27	446.0	4	454.0	38.3	0.00
% Perennial grass_0	28	446.6	4	454.7	39.0	0.00
Annual grass height_0.2 (Q)	29	445.0	5	455.1	39.4	0.00
Annual grass height_0.03	30	447.4	4	455.6	39.8	0.00
Perennial forb height_0.2	31	448.2	4	456.4	40.6	0.00
% Perennial grass_0 (Q)	32	446.2	5	456.4	40.7	0.00
Intercept-Only	33	450.6	3	456.6	40.9	0.00
Survival						
% Perennial grass_0.03	1	498.5	2	502.5	0.0	0.35
% Perennial grass_0	2	500.0	2	504.0	1.5	0.16
% Perennial grass_0.03 (Q)	3	498.5	3	504.5	2.0	0.13
% Perennial grass_0.2	4	501.1	2	505.1	2.6	0.10
% Bare ground_0	5	501.3	2	505.3	2.8	0.09
% Perennial grass_0 (Q)	6	500.0	3	506.0	3.6	0.06
Site	7	496.2	5	506.2	3.7	0.06
Intercept-Only	8	504.5	1	506.5	4.0	0.05
Ratio of Selection						
Perennial grass height_0.2	1	494.0	2	498.0	0.0	0.61
Perennial grass height_0.2 (Q)	2	494.0	3	500.0	2.0	0.23
% Perennial grass_0.03	3	498.5	2	502.5	4.5	0.07
% Perennial grass_0.03 (Q)	4	497.5	3	503.5	5.5	0.04
Intercept-Only	5	504.5	1	506.5	8.5	0.01
Residual cover height_0.3	6	502.9	2	506.9	8.9	0.01
Residual cover height_0.3 (Q)	7	500.9	3	506.9	8.9	0.01
% Residual cover_0 (Q)	8	501.1	3	507.1	9.1	0.01
% Bare ground_0	9	503.2	2	507.2	9.2	0.01
Annual grass height_0.3	10	503.9	2	507.9	10.0	0.00
% Bare ground_0 (Q)	11	502.2	3	508.2	10.2	0.00

% Residual cover	12	504.4	2	508.4	10.4	0.00
% Vertical cover	13	504.5	2	508.5	10.5	0.00
% Vertical cover (Q)	14	502.9	3	508.9	10.9	0.00
Annual grass height_0.3 (Q)	15	503.1	3	509.1	11.2	0.00

[a](Q) indicates that both the first order and quadratic term were included in the model.

Appendix S5. Description of models with more than one interaction term used to evaluate nest-site selection for ring-necked pheasant nests ($n = 163$) in the Central Valley, CA, 2014– 2017.

Model Name	Parameters[a]
Global 1(Base)	% Vertical cover (Q)
	% Residual cover_0 (Q)
	% Bare ground_0
	Perennial grass height_0.2
	Annual grass height_0.2
Global 2	Base
	% Vertical cover (Q)*% Residual cover (Q)
Global 3	Base
	% Vertical cover (Q)*% Bare ground_0
Global 4	Base
	% Vertical cover(Q)*Perennial grass height_0.2
Global 5	Base
	% Vertical cover(Q)*Annual grass height_0.2
Global 6	Base
	% Residual cover (Q)*% Bare ground_0
Global 7	Base
	% Residual cover(Q)*Perennial grass height_0.2
Global 8	Base
	% Residual cover(Q)*Annual grass height_0.2
Global 9	Base
	% Bare ground_0*Perennial grass height_0.2
Global 10	Base
	% Bare ground_0*Annual grass height_0.2
Global 11	Base
	Perennial grass height_0.2*Annual grass height_0.2
Global 12	Base
	Perennial grass height_0.2*% Perennial grass_0.03
Global 13	Base
	% Vertical cover (Q)*% Residual cover_0 (Q)
	% Bare ground_0*Perennial grass height_0.2
Global 14	Base
	% Vertical cover (Q)*% Residual cover_0 (Q)
	% Bare ground_0*Annual grass height_0.2
Global 15	Base
	% Vertical cover (Q)*% Residual cover_0 (Q)
	% Residual cover_0 (Q)*% Bare ground_0
Global 16	Base
	% Vertical cover (Q)*Annual grass height_0.2

Global 17	% Residual cover_0 (Q)*% Bare ground_0
	% Bare ground_0*Annual grass height_0.2
	Base
	% Vertical cover (Q)*Annual grass height_0.2
	% Residual cover_0 (Q)*% Bare ground_0

[a] (Q) indicates the quadratic term for variables with second order effects.

Appendix S6. Comparison of global models with combinations of interaction terms used to evaluate nest-site selection for ring-necked pheasant nests ($n = 163$) in the Central Valley, CA, 2014– 2017. Models ≥ 2 AIC_c units relative to the Base model were considered to be significant at contributing to probabilities of nest selection. -2 LL = deviance$; K$ = number of parameters; AIC_c = Akaike's Information Criterion with second order bias correction; ΔAIC_c = difference between model of interest and most explanatory model with second-order bias correction; w = model probability.

Model Name	Rank	-2LL	K	AIC_c	ΔAIC_c	w
Global 17	1	368.1	12	398.1	0.0	0.39
Global 16	2	366.6	13	393.7	0.6	0.29
Global 15	3	372.5	11	395.3	2.2	0.13
Global 6	4	374.2	11	397.1	3.9	0.06
Global 1 (Base)	5	378.3	10	399.0	5.8	0.02
Global 15	6	374.2	12	399.2	6.1	0.02
Global 7	7	376.6	11	399.4	6.3	0.02
Global 8	8	376.6	11	399.5	6.3	0.02
Global 10	9	377.3	11	400.1	7.0	0.01
Global 11	10	377.8	11	400.6	7.5	0.01
Global 9	11	378.0	11	400.9	7.7	0.01
Global 2	12	378.0	11	400.9	7.7	0.01
Global 4	13	378.2	11	401.0	7.9	0.01
Global 3	14	378.3	11	401.1	8.0	0.01
Global 14	15	377.0	12	402.0	8.9	0.00
Global 12	16	377.3	12	402.3	9.2	0.00
Global 13	17	377.8	12	402.8	9.6	0.00