

## Appendix

### Influence of phenology on site selection by female American black bears in coastal British Columbia

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**Abstract:** We examined factors that affect site selection by female American black bears (*Ursus americanus*) in coastal British Columbia, Canada, 1992–95. We monitored 9 radiocollared females and compared sites that were selected within their home ranges to those that were not selected using 1-1 matched logistic regression procedures. We used information-theoretic inference to assess the effect of 19 habitat, temporal, and spatial variables in 27 candidate models to explain selection of sites within home ranges. The model that best explained site selection was 50 times more likely to be the best model, given the data, than the second-best model. The best model suggested that the probability that a site would be used by female black bears increased with increasing values of phenologically adjusted berry value interacting with light levels, phenologically adjusted succulent forage value, and presence of forest harvesting. Probability of use decreased with increasing distance from streams dependent upon salmon (*Oncorhynchus* spp.) availability and increasing distance from low-traffic roads. Although the best model included horizontal visibility and distance to high-traffic roads as variables, these factors had undetermined effects on the probability of use (i.e., 95% confidence interval of odds ratio encompassed 1). Including phenological adjustments for abundance of berries and succulent foods greatly increased the support for the models by the data, compared to models based on cover of food plants alone. These results confirm that bears are cognizant of both temporal and spatial differences in food availability and that they modify their selection of sites based on these variations. Our results imply that site selection by female black bears involved a complex set of decisions about not only food availability, but also disturbance by humans. To increase the compatibility of timber production with the conservation of black bear habitat, managers need to consider the spatial and temporal effects of the creation of food-rich openings and different types of roads on the suitability and effectiveness of habitats to support black bears.

**Key words:** 1-1 matched logistic regression, Akaike's information criterion, American black bear, British Columbia, disturbance, forage, forest management, habitat, phenology, site selection, *Ursus americanus*

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Table 1. Plant scores for forage species for female American black bears in coastal British Columbia, Canada, 1992–95. Succulent and berry values were scored as 0.5 (low), 0.75 (medium) or 1.0 (high) for food preference and relative productivity/cover. See Table 2 for phenology curves.

Scientific name	Common name	Scored succulent value	Succulent phenology curve	Scored berry value	Berry phenology curve
<i>Amelanchier alnifolia</i>	Saskatoon serviceberry			0.75	V
<i>Arctostaphylos uva-ursi</i>	kinnikinnick			0.5	G
<i>Athyrium filix-femina</i>	lady fern	0.75	SU		
<i>Bromus vulgaris</i>	Columbia brome	0.5	SF		
<i>Calamagrostis rubescens</i>	pinegrass	0.75	SF		
<i>Carex</i> sp.	sedges	1	SU		
<i>Cirsium</i> sp.	thistles	0.5	SF		
<i>Cornus canadensis</i>	Bunchberry dogwood			0.5	V
<i>Cornus stolonifera</i>	red-osier dogwood			0.75	V
<i>Dryopteris expansa</i>	spiny woodfern	0.5	SU		
<i>Empetrum nigrum</i>	crowberry			0.5	V
<i>Epilobium angustifolium</i>	fireweed	0.75	SF		
<i>Equisetum</i> sp.	horsetails	1	SU		
<i>Festuca</i> sp.	fescue	1	SU		
<i>Fragaria</i> sp.	strawberries			1	F
<i>Fritillaria affinis</i>	chocolate lily	1	SF		
<i>Gaultheria shallon</i>	salal	0.5	R	0.75	G
<i>Heracleum maximum</i>	cowparsnip	0.75	SF		
<i>Hieracium scouleri</i>	western hawkweed	0.5	SU		
<i>Hypochaeris radicata</i>	hairy cat's-ear	0.75	SU		

Scientific name	Common name	Scored succulent value	Succulent phenology curve	Scored berry value	Berry phenology curve
<i>Lactuca muralis</i>	wall lettuce	1	SU		
<i>Lonicera involucrata</i>	black twinberry	0.5	SF	0.75	V
<i>Lysichiton americanus</i>	skunk cabbage	0.75	SU		
<i>Malus fusca</i>	Pacific crabapple			1	P
<i>Oenanthe sarmentosa</i>	Pacific water-parsley	0.5	V		
<i>Oplopanax horridus</i>	devil's club	0.5	SF	0.75	P
<i>Oryzopsis asperifolia</i>	rough-leaved ricegrass	1	SU		
<i>Petasites</i> sp.	coltsfoots	0.5	SF		
<i>Poa</i> sp.	bluegrasses	1	SU		
<i>Prunus emarginata</i>	bitter cherry			0.75	P
<i>Prunus virginiana</i>	choke cherry			0.75	P
<i>Rhamnus purshiana</i>	casacara	0.5	V	0.5	P
<i>Ribes bracteosum</i>	stink currant			0.5	P
<i>Ribes divaricatum</i>	wild gooseberry			0.75	P
<i>Ribes lacustre</i>	black gooseberry			0.75	P
<i>Ribes laxiflorum</i>	trailing black currant			0.75	P
<i>Ribes oxycanthoides</i>	northern gooseberry			0.75	P
<i>Ribes sanguineum</i>	red-flowering currant	0.75	SF	0.5	P
<i>Rosa</i> sp.	roses			0.75	O
<i>Rubus laciniatus</i>	evergreen blackberry			1	V

Scientific name	Common name	Scored succulent value	Succulent phenology curve	Scored berry value	Berry phenology curve
<i>Rubus leucodermis</i>	black raspberry			0.75	V
<i>Rubus parviflorus</i>	thimbleberry	0.75	SF	0.75	V
<i>Rubus pedatus</i>	five-leaved bramble			0.5	VP
<i>Rubus pubescens</i>	dwarf red raspberry	0.5	V		
<i>Rubus spectabilis</i>	salmonberry	1	SF	0.75	R
<i>Rubus ursinus</i>	trailing blackberry			1	RU
<i>Salix</i> sp.	willows	0.5	SF		
<i>Sambucus racemosa</i>	red elderberry			1	E
<i>Smilacina racemosa</i>	false Solomon's- seal	0.5	SF	0.5	VP
<i>Smilacina stellata</i>	star-flowered false Solomon's-seal	0.5	SF		
<i>Sonchus asper</i>	prickly sow-thistle	0.5	SF		
<i>Stachys mexicana</i>	Mexican hedge- nettle	0.5	SF		
<i>Streptopus</i> sp.	twistedstalks	0.5	SF	0.5	VP
<i>Taraxacum officinale</i>	common dandelion	0.75	SF		
<i>Trautvetteria caroliniensis</i>	false bugbane	0.5	SF		
<i>Trifolium</i> sp.	clovers	1	SU		
<i>Vaccinium alaskaense</i>	Alaskan blueberry			1	V
<i>Vaccinium caespitosum</i>	dwarf blueberry			1	V
<i>Vaccinium</i> sp.	blueberry, huckleberry			1	V
<i>Vaccinium membranaceum</i>	black huckleberry			1	V
<i>Vaccinium ovalifolium</i>	oval-leaved blueberry			1	V

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<b>Scientific name</b>	<b>Common name</b>	<b>Scored succulent value</b>	<b>Succulent phenology curve</b>	<b>Scored berry value</b>	<b>Berry phenology curve</b>
<i>Vaccinium oxycoccus</i>	bog cranberry			0.75	G
<i>Vaccinium parvifolium</i>	red huckleberry			1	VP
<i>Vaccinium uliginosum</i>	bog blueberry			1	V
<i>Valeriana</i> sp.	valerian	0.5	SF		
<i>Viburnum edule</i>	highbush-cranberry			0.5	V

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Table 2. Candidate and 95% CI set of *a priori* models for the information-theoretic examination of factors affecting site selection within home ranges by female American black bears during the non-denning period in coastal British Columbia, 1992–95. Models are ordered by descending strength of evidence. Variables are defined in Appendix Table 3. The first letter in the model ID refers to the type of variables included in the model: F = food only, S = security/displacement only, C = combination food and security or displacement. Other parameters are log likelihood ( $\log \mathcal{L}$ ), number of estimated parameters ( $K$ ), Akaike's information criterion (AIC) score, difference between AIC score and the minimum AIC score for the candidate set ( $\Delta_{\text{AIC}}$ ), and Akaike weight (strength of evidence,  $w_i$ ).

Model ID	Variables of interest	$\log(\mathcal{L})$	K	AIC	$\Delta_{\text{AIC}}$	$w_i$
C18	BERRY_VALUE*LIGHT SUCC_VALUE PROX_FISH*SALMON HORIZ_CVR PROX_HIGH PROX_LOW LOGGING	-456.035	7	926.070	0	0.973
C7	BERRY_VALUE*LIGHT SUCC_VALUE PROX_HIGH PROX_LOW HORIZ_CVR ESC_TREES*DEP_YOUNG	-460.957	6	933.914	7.844	0.019
C6	BERRY_VALUE*LIGHT SUCC_VALUE PROX_ESC HORIZ_CVR PROX_HIGH PROX_LOW	-461.962	6	935.925	9.854	0.007
F18	BERRY_VALUE*LIGHT SUCC_VALUE PROX_FISH*SALMON	-468.603	3	943.207	17.137	<0.001
F19	BERRY_VALUE*LIGHT SUCC_VALUE	-470.568	2	945.136	19.066	<0.001
C16	BERRY_VALUE*LIGHT SUCC_VALUE HORIZ_CVR	-469.669	3	945.337	19.267	<0.001
C15	BERRY_VALUE*LIGHT SUCC_VALUE PROX_ESC	-470.421	3	946.841	20.771	<0.001
C17	BERRY_CVR SUCC_CVR PROX_FISH*SALMON CAN_CLOSE PROX_ESC HORIZ_CVR PROX_HIGH PROX_LOW LOGGING	-478.720	9	975.440	49.370	<0.001
S9	ST_STAGE_F PROX_HIGH PROX_LOW	-486.746	3	979.492	53.422	<0.001
S6	HORIZ_CVR ESC_TREES PROXROAD	-488.730	3	983.461	57.391	<0.001
F10	ST_STAGE0_3 ST_STAGE4_3 ST_STAGE5_3 ST_STAGE6_3 ST_STAGE7_3	-488.160	5	986.320	60.250	<0.001
S10	HORIZ_CVR ESC_TREES PROXROAD*HUNTING	-492.639	3	991.279	65.208	<0.001
S8	HORIZ_CVR ESC_TREES	-495.582	2	995.164	69.094	<0.001
F1	CAN_CLOSE	-498.326	1	998.652	72.582	<0.001

Model ID	Variables of interest	$\log(\mathcal{L})$	K	AIC	$\Delta_{AIC}$	$w_i$
S7	ESC_TREES	-498.389	1	998.778	72.708	<0.001
S3	HORIZ_CVR*DEP_YOUNG ESC_TREES	-498.042	2	1000.084	74.014	<0.001
C3	BERRY_CVR SUCC_CVR PROX_ESC HORIZ_CVR PROX_HIGH PROX_LOW	-495.977	6	1003.954	77.884	<0.001
C4	BERRY_CVR SUCC_CVR PROX_HIGH PROX_LOW HORIZ_CVR ESC_TREES*DEP_YOUNG	-496.140	6	1004.281	78.211	<0.001
C12	BERRY_CVR SUCC_CVR HORIZ_CVR	-501.874	3	1009.747	83.677	<0.001
F8	BERRY_CVR SUCC_CVR	-503.499	2	1010.998	84.928	<0.001
F6	BERRY_CVR SUCC_CVR PROX_FISH	-503.229	3	1012.458	86.388	<0.001
C11	BERRY_CVR SUCC_CVR PROX_ESC	-503.341	3	1012.683	86.613	<0.001
S1	ST_STAGE0_3*HUNTING ST_STAGE4_3*HUNTING ST_STAGE5_3*HUNTING ST_STAGE6_3*HUNTING ST_STAGE	-505.267	5	1020.534	94.464	<0.001
S4	ST_STAGE_F*DEP_YOUNG PROX_HIGH PROX_LOW	-507.336	3	1020.673	94.603	<0.001
S2	ESC_TREES*DEP_YOUNG	-519.029	1	1040.059	113.989	<0.001
S11	PROX_ESC	-521.957	1	1045.915	119.844	<0.001
S5	PROX_ESC*DEP_YOUNG	-522.762	1	1047.524	121.454	<0.001

Table 3. Spatial and habitat variables used in candidate models for the examination of factors affecting site selection within home ranges by radiocollared female American black bears in coastal British Columbia, Canada, 1992–95.

Variable	Definition
BERRY_CVR	Cover (%) of berry-producing shrubs known to be used by bears.
SUCC_CVR	Cover (%) of succulent plant species known to be used by bears.
BERRY_VALUE	Phenologically adjusted estimate of scored berry value and productivity. Phenological development was specific to the date of each radiolocation. Derived from the product of BERRY_CVR, food value score, and date-specific phenological development of each berry-producing species. Values range between 0 and 100.
SUCC_VALUE	Phenologically adjusted estimate of scored succulent value and productivity. Phenological development was specific to the date of radiolocation. Derived from the product of SUCC_CVR, food value score, and date-specific phenological development of each succulent-producing species. Values range between 0 and 100.
PROX_FISH	Distance (m) to rivers that have spawning anadromous salmon ( <i>Oncorhynchus</i> spp.).
SALMON	Seasonally adjusted abundance of salmon.
ST_STAGE_F	Structural stage transformed to continuous variable based on logistic transformation of predicted food productivity in each structural stage. Food values were ranked as: Recently disturbed or sparsely vegetated = 0.1 Herb–shrub = 0.9 Pole–sapling = 0.5 Young forest = 0.1 Mature forest = 0.2 Old forest = 0.4
CAN_CLOSE	Canopy closure (%)
LIGHT	Relative measure of light making its way to the shrub layer. Derived from inverse of canopy closure ( $1/[\text{CAN\_CLOSE}+1]$ ).

Variable	Definition
ST_STAGE	<p>Structural stage: categorical variable with 6 levels:</p> <p>0 &amp; 1: water, railway, road, urban, rural, or sparsely vegetated</p> <p>2 &amp; 3: herb–shrub, &gt;20% shrub cover, ≤10% tree cover ≤10 m tall</p> <p>4: pole–sapling, &gt;10 m tall and ≤40 years (conifer) ≤30 years (deciduous)</p> <p>5: young forest, &gt;10 m tall, 40–80 years (conifer) or 30–60 years (deciduous)</p> <p>6: mature forest, &gt;10 m tall and 81–249 years (conifer) or &gt;60 years (deciduous)</p> <p>7: old forest, &gt;10 m tall and ≥250 years</p> <p>Transformed into 5 binary design variables, with reference to the herb–shrub structural stage 3: ST_STAGE0_3, ST_STAGE4_3, ST_STAGE5_3, ST_STAGE6_3, ST_STAGE7_3</p>
S_GROUP	<p>Site group based on amalgamation of site series with similar floristic and structural characteristics. Categorical variable transformed into 14 design variables (S_GROUP_XXX_FSA), with reference value set to the Fir (<i>Pseudotsuga menziesii</i>)–salal site group.</p>
LOGGING	Whether stand had been logged.
ESC_TREES	Presence or absence of escape trees — defined as stands with climbable trees (young forest and older structural stages).
PROX_ESC	Distance (m) to stands with escape trees (stands in young forest or older structural stage).
HORIZ_VIS	Average distance (m) at which black bears would be hidden by vegetation or topography.
PROX_HIGH	Distance (m) to nearest main haul road or highway.
PROX_LOW	Distance (m) to nearest spur road or railroad corridor.
HUNTING	Hunting season (opened, closed).
DEP_YOUNG	Presence or absence of dependent young.

Table 1. Plant scores for forage species for female American black bears in coastal British Columbia, Canada, 1992–95. Succulent and berry values were scored as 0.5 (low), 0.75 (medium) or 1.0 (high) for food preference and relative productivity/cover. See Table 2 for phenology curves.

Scientific name	Common name	Scored succulent value	Succulent phenology curve	Scored berry value	Berry phenology curve
<i>Amelanchier alnifolia</i>	Saskatoon serviceberry			0.75	V
<i>Arctostaphylos uva-ursi</i>	kinnikinnick			0.5	G
<i>Athyrium filix-femina</i>	lady fern	0.75	SU		
<i>Bromus vulgaris</i>	Columbia brome	0.5	SF		
<i>Calamagrostis rubescens</i>	pinegrass	0.75	SF		
<i>Carex</i> sp.	sedges	1	SU		
<i>Cirsium</i> sp.	thistles	0.5	SF		
<i>Cornus canadensis</i>	Bunchberry dogwood			0.5	V
<i>Cornus stolonifera</i>	red-osier dogwood			0.75	V
<i>Dryopteris expansa</i>	spiny woodfern	0.5	SU		
<i>Empetrum nigrum</i>	crowberry			0.5	V
<i>Epilobium angustifolium</i>	fireweed	0.75	SF		
<i>Equisetum</i> sp.	horsetails	1	SU		
<i>Festuca</i> sp.	fescue	1	SU		
<i>Fragaria</i> sp.	strawberries			1	F
<i>Fritillaria affinis</i>	chocolate lily	1	SF		
<i>Gaultheria shallon</i>	salal	0.5	R	0.75	G
<i>Heracleum maximum</i>	cowparsnip	0.75	SF		
<i>Hieracium scouleri</i>	western hawkweed	0.5	SU		
<i>Hypochaeris radicata</i>	hairy cat's-ear	0.75	SU		
<i>Lactuca muralis</i>	wall lettuce	1	SU		
<i>Lonicera involucrata</i>	black twinberry	0.5	SF	0.75	V
<i>Lysichiton americanus</i>	skunk cabbage	0.75	SU		
<i>Malus fusca</i>	Pacific crabapple			1	P
<i>Oenanthe sarmentosa</i>	Pacific water-parsley	0.5	V		

Scientific name	Common name	Scored succulent value	Succulent phenology curve	Scored berry value	Berry phenology curve
<i>Oplopanax horridus</i>	devil's club	0.5	SF	0.75	P
<i>Oryzopsis asperifolia</i>	rough-leaved ricegrass	1	SU		
<i>Petasites</i> sp.	coltsfoots	0.5	SF		
<i>Poa</i> sp.	bluegrasses	1	SU		
<i>Prunus emarginata</i>	bitter cherry			0.75	P
<i>Prunus virginiana</i>	choke cherry			0.75	P
<i>Rhamnus purshiana</i>	casacara	0.5	V	0.5	P
<i>Ribes bracteosum</i>	stink currant			0.5	P
<i>Ribes divaricatum</i>	wild gooseberry			0.75	P
<i>Ribes lacustre</i>	black gooseberry			0.75	P
<i>Ribes laxiflorum</i>	trailing black currant			0.75	P
<i>Ribes oxycanthoides</i>	northern gooseberry			0.75	P
<i>Ribes sanguineum</i>	red-flowering currant	0.75	SF	0.5	P
<i>Rosa</i> sp.	roses			0.75	O
<i>Rubus laciniatus</i>	evergreen blackberry			1	V
<i>Rubus leucodermis</i>	black raspberry			0.75	V
<i>Rubus parviflorus</i>	thimbleberry	0.75	SF	0.75	V
<i>Rubus pedatus</i>	five-leaved bramble			0.5	VP
<i>Rubus pubescens</i>	dwarf red raspberry	0.5	V		
<i>Rubus spectabilis</i>	salmonberry	1	SF	0.75	R
<i>Rubus ursinus</i>	trailing blackberry			1	RU
<i>Salix</i> sp.	willows	0.5	SF		
<i>Sambucus racemosa</i>	red elderberry			1	E
<i>Smilacina racemosa</i>	false Solomon's-seal	0.5	SF	0.5	VP
<i>Smilacina stellata</i>	star-flowered false Solomon's-seal	0.5	SF		

Scientific name	Common name	Scored succulent value	Succulent phenology curve	Scored berry value	Berry phenology curve
<i>Sonchus asper</i>	prickly sow-thistle	0.5	SF		
<i>Stachys mexicana</i>	Mexican hedge-nettle	0.5	SF		
<i>Streptopus</i> sp.	twistedstalks	0.5	SF	0.5	VP
<i>Taraxacum officinale</i>	common dandelion	0.75	SF		
<i>Trautvetteria caroliniensis</i>	false bugbane	0.5	SF		
<i>Trifolium</i> sp.	clovers	1	SU		
<i>Vaccinium alaskaense</i>	Alaskan blueberry			1	V
<i>Vaccinium caespitosum</i>	dwarf blueberry			1	V
<i>Vaccinium</i> sp.	blueberry, huckleberry			1	V
<i>Vaccinium membranaceum</i>	black huckleberry			1	V
<i>Vaccinium ovalifolium</i>	oval-leaved blueberry			1	V
<i>Vaccinium oxycoccus</i>	bog cranberry			0.75	G
<i>Vaccinium parvifolium</i>	red huckleberry			1	VP
<i>Vaccinium uliginosum</i>	bog blueberry			1	V
<i>Valeriana</i> sp.	valerian	0.5	SF		
<i>Viburnum edule</i>	highbush-cranberry			0.5	V