

Ecography

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**Supplementary material**

## Appendix 1

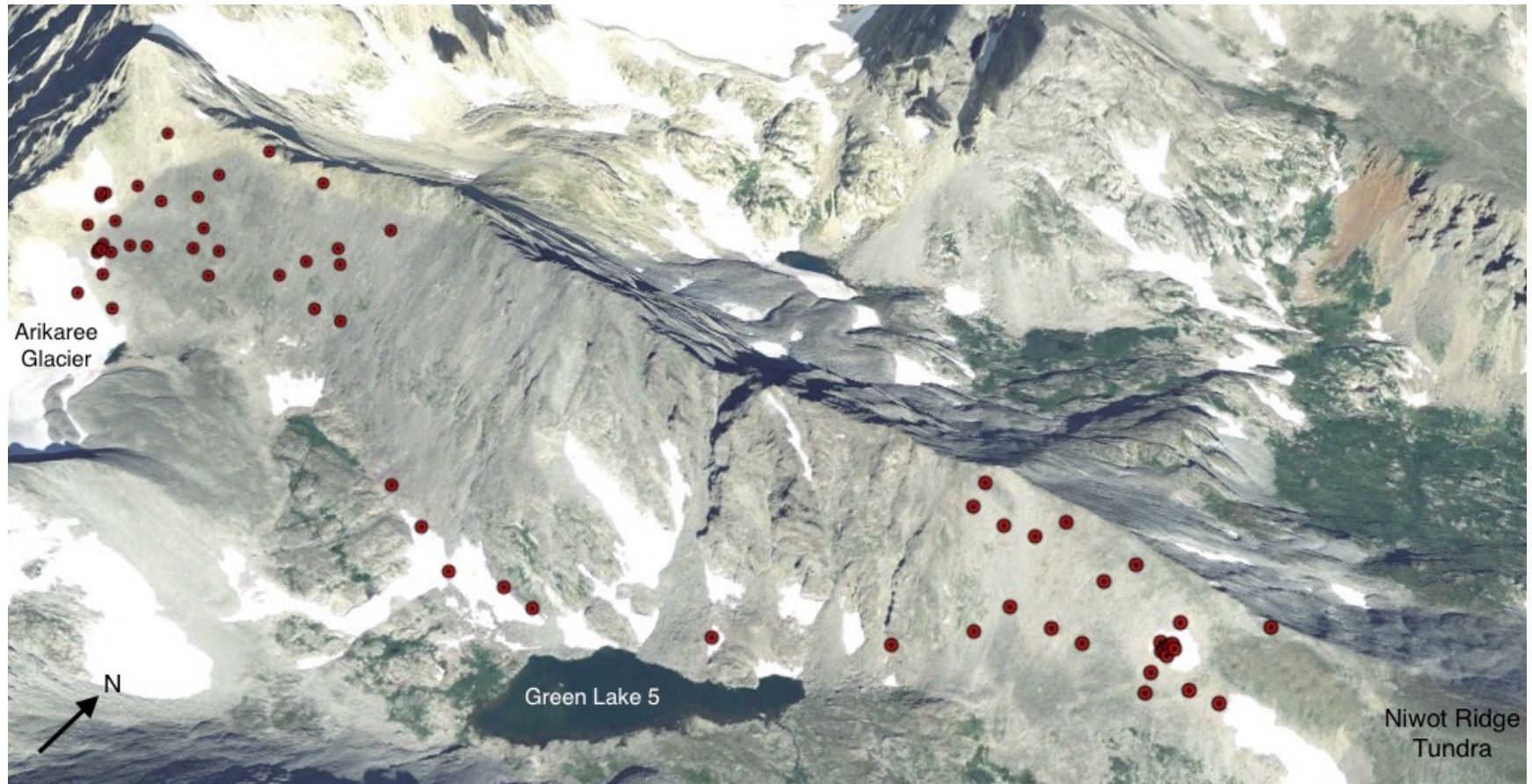


Figure A1. The 66 sample sites in the subnival zone of the Green Lakes Valley within the Niwot Ridge LTER study site on the eastern face of the Continental Divide in Colorado USA. The study area is 2 km from northeast corner to northwest corner. These sites are a

subset of the sites in our previous studies (King et al. 2010, 2012). The scarcity of plots in the middle of the study area is due to a large cliff face with no soil or plants.

## Appendix 2

Table A2. Taxonomical designations of the clades used in our modeling analyses (*italicized*) as well as their mean relative abundances across the 66 sampling locations.

<b>Phylum</b>	<b>Subgroup</b>	<b>Class</b>	<b>Order</b>	<b>Family</b>	<b>Mean Relative Abundance</b>
Acidobacteria	<i>Acidobacteria Gp1</i>				0.01222
Acidobacteria	<i>Acidobacteria Gp3</i>				0.01116
Acidobacteria	<i>Acidobacteria Gp7</i>				0.02936
Actinobacteria		Actinobacteria	<i>Actinomycetales</i>		0.02302
Proteobacteria		Betaproteobacteria	<i>Burkholderiales</i>		0.01314
Firmicutes		Clostridia	<i>Clostridiales*</i>		0.01094
<i>Cyanobacteria</i>					0.01462
Proteobacteria		<i>Deltaproteobacteria</i>			0.05186
Chloroflexi		Ktedonobacteria	Ktedonobacterales	<i>Ktedonobacteraceae</i>	0.05203
Proteobacteria		Betaproteobacteria	Burkholderiales	<i>Oxalobacteraceae</i>	0.02837
Actinobacteria		Actinobacteria	Actinomycetales	<i>Pseudonocardiaceae</i>	0.01172
Proteobacteria		Alphaproteobacteria	<i>Rhodospirillales</i>		0.02285
Acidobacteria		Actinobacteria	Rubrobacterales	<i>Rubrobacteraceae*</i>	0.01147
Proteobacteria		Alphaproteobacteria	Sphingomonadales	<i>Sphingomonadaceae</i>	0.01243
<i>TM7</i>					0.00875

\*Did not improve any plant SDM

### Appendix 3

Table A3. Elevation average (at our study site), functional group, and specialist type of the modeled species.

<b>Plant</b>	<b>Elevation Average (m)</b>	<b>Functional Group</b>	<b>Specialist/Generalist</b>
<i>Carex nardina</i>	3775	Graminoid	Talus Specialist
<i>Carex phaeocephala</i>	3788	Graminoid	Talus Specialist
<i>Deschampsia cespitosa</i>	3748	Graminoid	Tundra Generalist
<i>Elymus scriberneri</i>	3796	Graminoid	Tundra Generalist
<i>Festuca rubra</i>	3813	Graminoid	Tundra Generalist
<i>Kobresia myosuroides</i>	3759	Graminoid	Tundra Generalist
<i>Trisetum spicatum</i>	3789	Graminoid	Tundra Generalist
<i>Cirsium scopulorum</i>	3792	Forb	Talus Specialist
<i>Geum rossii</i>	3770	Forb	Tundra Generalist
<i>Oxyria digyna</i>	3743	Forb	Talus Specialist
<i>Senecio fremontii</i>	3791	Forb	Talus Specialist
<i>Silene acaulis</i>	3802	Forb	Tundra Generalist
<i>Bryophytes</i>	3784	Bryophyte	Tundra Generalist

## Appendix 4

Table A4 . Model parameters and results (AICc = corrected Akaike Information Criterion; Pseudo R<sup>2</sup> = Nagelkerke's R<sup>2</sup>, AUC = area under the curve). Error is from 10-fold cross validation, adjusted for not using leave one out. Independence of errors was tested with the Durbin-Watson test (P-value in parentheses) and multicollinearity was tested with VIF statistics (average VIF in parentheses).

Bolded numbers are the lowest AICc and error values, and highest R<sup>2</sup>, D<sup>2</sup>, and AUC values of the four models for each plant. **Abiotic Factors:** ALT = altitude; Snow = snowpack; Dpinorg = dissolved inorganic phosphorus; DOC = dissolved organic carbon; Dptotal = total dissolved phosphorus; TDN = total dissolved nitrogen; Sand = % sand. **Plant Factors:** descas = *Deschampsia cespitosa*; hymgra = *Hymenoxys grandiflora*; kobmyo = *Kobresia myosuroides*; *Carex perglobosa*; senfre = *Senecio fremontii*; carnar = *Carex nardina*; anggra = *Angelica grayi*; trispi = *Trisetum spicatum*; carpha = *Carex phaeocephala*; geuros = *Geum rossii*; elyscr = *Elymus scriberneri*; fesrub = *Festuca rubra*; antalp = *Antennaria alpina*; phlsib = *Phlox siberica*. **Bacteria Factors:** rhodo = Rhodospirillales; acidGP3 = Acidobacteria Gp3; acidGP1 = Acidobacteria Gp1; acidGP7 = Acidobacteria Gp7; oxalo = Oxalobacteraceae; sphingo = Sphingomonadaceae; pseudo = Pseudonocardiaceae; delta = Deltaproteobacteria; cyano = Cyanobacteria; burk = Burkholderiales; ktedo = Ktedonobacteraceae; actinomyc = Actinomycetales.

Plant	Model	Predictor Variables	ΔAICc	AICc	Pseudo R <sup>2</sup>	Adj. D <sup>2</sup>	AUC	Error	Ind. Errors	Multicollin.
<i>Carex nardina</i>	ABIOT+PLANT	ALT+Soil H2O+Snow+Dpinorg+DOC+descas+hymgra+kobmyo+moss	0.0000	<b>69.1591</b>	0.645	0.401	0.9190	<b>0.1926</b>	Yes (0.12)	No (1.73)
	FULL	ALT+Soil H2O+Snow+Dpinorg+DOC+descas+hymgra+kobmyo+moss+rhodo	0.3459	69.5050	<b>0.672</b>	<b>0.425</b>	<b>0.9259</b>	0.1995	Yes (0.13)	No (2.13)
	ABIOT+BACT	ALT+Soil H2O+Snow+Dpinorg+DOC+acidGP3+rhodo	9.2779	78.4370	0.466	0.233	0.8507	0.1988	Yes (0.99)	No (1.89)
	ABIOT	ALT+Soil H2O+Snow+Dpinorg+DOC	11.2705	80.4296	0.364	0.171	0.8293	0.2013	Yes (0.95)	No (1.97)
<i>Carex phaeocephala</i>	FULL	Dptotal+carper+senfre+acidGP1	0.0000	<b>48.5399</b>	<b>0.429</b>	<b>0.287</b>	<b>0.8804</b>	0.1357	No (0.01)	No (1.30)
	ABIOT+PLANT	Dptotal+carper+senfre	0.7427	49.2826	0.366	0.241	0.8446	0.1361	No (0.03)	No (1.32)

Plant	Model	Predictor Variables	$\Delta AICc$	AICc	Pseudo R <sup>2</sup>	Adj. D <sup>2</sup>	AUC	Error	Ind. Errors	Multicollin.
	ABIOT+BACT	Dptotal+acidGP1	1.4302	49.9701	0.303	0.199	0.8482	0.1315	No (0.01)	No (1.04)
	ABIOT	Dptotal	3.0298	51.5697	0.217	0.143	0.7821	<b>0.1239</b>	No (0.01)	NA
<i>Deschampsia</i>	FULL	pH+Soil H2O+Dptotal+carnar+senfre+acidGP1+acidGP7	0.0000	<b>69.0363</b>	<b>0.519</b>	<b>0.304</b>	<b>0.8812</b>	<b>0.1808</b>	Yes (0.34)	No (1.51)
<i>cespitosa</i>	ABIOT+PLANT	pH+Soil H2O+Dptotal+carnar+senfre	5.6455	74.6818	0.368	0.192	0.8223	0.1892	No (0.03)	No (1.28)
	ABIOT+BACT	pH+Soil H2O+Dptotal+acidGP1+acidGP7	8.3621	77.3984	0.364	0.175	0.8037	0.2029	Yes (0.31)	No (1.23)
	ABIOT	pH+Soil H2O+Dptotal	11.8396	80.8759	0.227	0.099	0.7407	0.2188	No (0.04)	No (1.01)
<i>Elymus</i>	FULL	Snow+anggra+delta+acidGP1	0.0000	<b>44.7362</b>	<b>0.452</b>	<b>0.316</b>	<b>0.8928</b>	0.1146	Yes (0.62)	No (1.08)
<i>scriberneri</i>	ABIOT+BACT	Snow+delta	0.5523	45.2885	0.341	0.237	0.8499	0.1071	Yes (0.62)	No (1.02)
	ABIOT+PLANT	Snow+anggra	1.5741	46.3103	0.318	0.217	0.8265	0.1064	Yes (0.83)	No (1.01)
	ABIOT	Snow	2.0510	46.7872	0.256	0.177	0.8051	<b>0.1043</b>	Yes (0.85)	NA
<i>Festuca</i>	ABIOT+PLANT	ALT+TDN+trisp+carpha+geuros+kobmyo+elyscr	0.0000	<b>74.9179</b>	0.548	0.307	0.8765	0.2189	Yes (0.44)	No (1.59)
<i>rubra</i>	FULL	ALT+TDN+trisp+carpha+geuros+kobmyo+elyscr+acidGP3	1.5341	76.4520	<b>0.561</b>	<b>0.310</b>	<b>0.8728</b>	0.2307	Yes (0.81)	No (1.81)
	ABIOT	ALT+TDN	5.2851	80.2030	0.310	0.165	0.7677	<b>0.2045</b>	Yes (0.69)	No (1.00)
	ABIOT+BACT	ALT+TDN+oxalo	6.0160	80.9339	0.334	0.170	0.7696	0.2055	Yes (0.85)	No (1.01)
<i>Kobresia</i>	ABIOT+BACT	ALT+acidGP3	0.0000	<b>69.3965</b>	0.212	0.111	0.7425	<b>0.1710</b>	Yes (0.82)	No (1.00)
<i>mysuroides</i>	FULL	ALT+fesrub+acidGP3+sphingo	0.1244	69.5209	<b>0.296</b>	<b>0.147</b>	<b>0.7875</b>	0.1723	Yes (0.91)	No (1.22)
	ABIOT	ALT	2.2129	71.6094	0.123	0.063	0.7038	0.1729	Yes (0.93)	NA
	ABIOT+PLANT	ALT+fesrub	2.3625	71.7590	0.165	0.077	0.7263	0.1749	Yes (0.74)	No (1.22)
<i>Trisetum</i>	FULL	Snow+Sand+antalp++anggra+TM7+pseudo	0.0000	<b>78.3555</b>	<b>0.465</b>	<b>0.240</b>	<b>0.8546</b>	0.1950	Yes (0.28)	No (1.21)
<i>spicatum</i>	ABIOT+PLANT	Snow+Sand+antalp+anggra	1.4280	79.7835	0.376	0.190	0.8299	0.1942	Yes (0.23)	No (1.15)
	ABIOT+BACT	Snow+Sand+pseudo+TM7	1.4561	79.8116	0.376	0.190	0.8285	<b>0.1914</b>	Yes (0.25)	No (1.14)
	ABIOT	Snow+Sand	3.9140	82.2695	0.267	0.135	0.7796	0.2139	Yes (0.19)	No (1.05)
<i>Cirsium</i>	FULL	Snow+ALT+Soil H2O+carpha+phlsib+silaca+delta	0.0000	<b>43.3514</b>	<b>0.811</b>	<b>0.656</b>	<b>0.9728</b>	<b>0.1277</b>	Yes (0.64)	No (3.46)
<i>scopulorum</i>	ABIOT+PLANT	Snow+ALT+Soil H2O+carpha+phlsib+silaca	5.2532	48.6046	0.734	0.555	0.9543	0.1632	Yes (0.79)	No (1.68)
	ABIOT+BACT	Snow+ALT+Soil H2O+delta+TM7	6.6180	49.9694	0.693	0.511	0.9467	0.1361	Yes (0.97)	No (1.58)
	ABIOT	Snow+ALT+Soil H2O	9.1262	52.4776	0.609	0.433	0.9152	0.1395	Yes (0.93)	No (1.46)
<i>Geum</i>	FULL	DOC+Dpinorg+Dptotal+carpha+hymgra+cyano+delta	0.0000	<b>50.1202</b>	<b>0.580</b>	<b>0.405</b>	<b>0.9256</b>	0.1555	Yes (0.25)	No (3.36)
<i>rossii</i>	ABIOT+PLANT	DOC+Dpinorg+Dptotal+carpha+hymgra	1.0731	51.1933	0.472	0.312	0.8678	<b>0.1390</b>	Yes (0.20)	No (3.50)
	ABIOT+BACT	DOC+Dpinorg+Dptotal+cyano	8.1754	58.2956	0.284	0.153	0.8281	0.1466	Yes (0.06)	No (3.16)
	ABIOT	DOC+Dpinorg+Dptotal	8.2403	58.3605	0.232	0.124	0.7818	0.1600	No (0.02)	No (4.40)
<i>Oxyria</i>	FULL	Snow+Soil H2O+pH+Dpinorg+carpha+fesrub+pseudo+delta	0.0000	<b>41.9309</b>	<b>0.796</b>	<b>0.654</b>	<b>0.9753</b>	0.1573	No (0.02)	Yes (5.43)
<i>digyna</i>	ABIOT+BACT	Snow+Soil H2O+pH+Dpinorg+acidGP7+delta+pseudo	1.4259	43.3568	0.748	0.592	0.9643	0.1320	No (0.01)	No (2.59)
	ABIOT+PLANT	Snow+Soil H2O+pH+Dpinorg+carpha+fesrub	2.3049	44.2358	0.704	0.543	0.9451	<b>0.1235</b>	No (0.02)	No (3.48)
	ABIOT	Snow+Soil H2O+pH+Dpinorg	5.0837	47.0146	0.599	0.437	0.9121	0.1253	No (0.01)	No (2.43)

<b>Plant</b>	<b>Model</b>	<b>Predictor Variables</b>	<b><math>\Delta</math>AICc</b>	<b>AICc</b>	<b>Pseudo R<sup>2</sup></b>	<b>Adj. D<sup>2</sup></b>	<b>AUC</b>	<b>Error</b>	<b>Ind. Errors</b>	<b>Multicollin.</b>
<i>Senecio</i>	ABIOT+ BACT	pH+oxalo+burk+ktedo	0.0000	<b>66.1767</b>	0.518	<b>0.320</b>	0.8760	0.1703	Yes (0.93)	No (1.23)
<i>fremontii</i>	FULL	pH+moss+oxalo+burk+ktedo	1.8553	68.0320	<b>0.525</b>	0.316	<b>0.8810</b>	<b>0.1594</b>	Yes (0.86)	No (1.22)
	ABIOT+PLANT	pH+moss	8.2514	74.4281	0.334	0.189	0.8016	0.1910	Yes (0.75)	No (1.02)
	ABIOT	pH	9.7644	75.9411	0.275	0.158	0.7798	0.1957	Yes (0.76)	NA
<i>Silene</i>	FULL	DOC+Snow+ALT+geuros+anggra+trisp+fesrub+burk	0.0000	<b>36.5904</b>	<b>0.845</b>	<b>0.732</b>	<b>0.9840</b>	0.1149	Yes (0.53)	No (2.94)
<i>acaulis</i>	ABIOT+PLANT	DOC+Snow+ALT+geuros+anggra+trisp+fesrub	4.9522	41.5426	0.754	0.606	0.9681	<b>0.1109</b>	Yes (0.93)	No (1.52)
	ABIOT+BACT	DOC+Snow+ALT+acidGP1+actinomyc	9.0102	45.6006	0.630	0.467	0.9260	0.1281	Yes (0.24)	No (1.56)
	ABIOT	DOC+Snow+ALT	16.2150	52.8054	0.439	0.293	0.8824	0.1348	Yes (0.06)	No (1.24)
<i>Bryophytes</i>	FULL	Snow+ALT+carper+kobmyo+rhodo	0.0000	<b>81.5441</b>	<b>0.395</b>	<b>0.191</b>	<b>0.8074</b>	0.2337	Yes (0.06)	No (1.36)
	ABIOT+PLANT	Snow+ALT+carper+kobmyo	0.8828	82.4269	0.346	0.165	0.7825	0.2292	Yes (0.10)	No (1.43)
	ABIOT+BACT	Snow+ALT+rhodo+oxalo	1.1069	82.6510	0.343	0.163	0.7935	<b>0.2045</b>	Yes (0.08)	No (1.41)
	ABIOT	Snow+ALT	3.5419	85.0860	0.231	0.110	0.7336	0.2228	Yes (0.10)	No (1.67)



## Appendix 5

Table A5 . Frequency and direction of abiotic factors included in the best fit ABIOT model of the plants. carnar = *Carex nardina*, carpha = *Carex phaeocephala*, descsc = *Deschampsia cespitosa*, elyscr = *Elymus scriberneri*, fesrub = *Festuca rubra*, kobmyo = *Kobresia myosuroides*, trispi = *Trisetum spicatum*, cirscs = *Cirsium scopulorum*, geuros = *Geum rossii*, oxydig = *Oxyria digyna*, senfre = *Senecio fremontii*, silaca = *Silene acaulis*. DOC = dissolved organic carbon, Dpinorg = dissolved inorganic phosphorus, Dptotal = total dissolved phosphorus, TDN = total dissolved nitrogen.

<b>Abiotic Predictor</b>	<b>Positive</b>	<b>Plant</b>	<b>Negative</b>	<b>Plant</b>
Snow Depth	3	carnar, oxydig, bryophytes	4	elyscr, trispi, cirscs, silaca
Elevation	4	carnar, fesrub, silaca, bryophytes	2	kobmyo, cirscs
Soil Moisture	1	cirscs	3	carnar, descsc, oxydig
DOC	3	carnar, geuros, silaca	0	
Dpinorg	1	geuros	2	carnar, descsc
Dptotal	0		3	carpha, descsc, geuros
pH	3	descae, oxydig, senfre	0	
Sand	1	trispi	0	
TDN	1	fesrub	0	
	<b>17</b>		<b>14</b>	

## Appendix 6

Table A6. Frequency and direction of plant-plant interactions. elyscr = *Elymus scriberneri*, trispi = *Trisetum spicatum*, silaca = *Silene acaulis*, carnar = *Carex nardina*, senfre = *Senecio fremontii*, desces = *Deschampsia cespitosa*, carpha = *Carex phaeocephala*, geuros = *Geum rossii*, fesrub = *Festuca rubra*, cirsko = *Cirsium scopulorum*, oxydig = *Oxyria digyna*, kobmyo = *Kobresia myosuroides*.

<b>Plant Predictor</b>	<b>Positive</b>	<b>Modeled Species</b>	<b>Negative</b>	<b>Modeled Species</b>
<i>Angelica grayi</i>	3	elyscr, trispi, silaca	0	
<i>Antennaria alpina</i>	0		1	trispi
<i>Bryophytes</i>	1	carnar	1	senfre
<i>Carex nardina</i>	1	desces	0	
<i>Carex perglobosa</i>	1	carpha	1	bryophytes fesrub, cirsko,
<i>Carex phaeocephala</i>	1	geuros	3	oxydig
<i>Deschampsia cespitosa</i>	1	carnar	0	
<i>Elymus scriberneri</i>	1	fesrub	0	
<i>Festuca rubra</i>	1	silaca	2	kobmyo, oxydig
<i>Geum rossii</i>	2	fesrub, silaca	0	
<i>Hymenoxis grandiflora</i>	2	carnar, geuros	0	
<i>Kobresia myosuroides</i>	1	carnar	2	fesrub, bryophytes
<i>Phlox siberica</i>	0		1	cirsko
<i>Senecio fremontii</i>	1	carpha	1	desces
<i>Silene acaulis</i>	1	cirsko	0	
<i>Trisetum spicatum</i>	1	fesrub	1	silaca
	<b>18</b>		<b>13</b>	