Diane M. Debinski, Jennet C. Caruthers, Dianne Cook, Jason Crowley, and Hadley Wickham. 2013. Gradient-based habitat affinities predict species vulnerability to drought. *Ecology*

Appendix B: Mixed effects model incorporating habitat affinity

Data

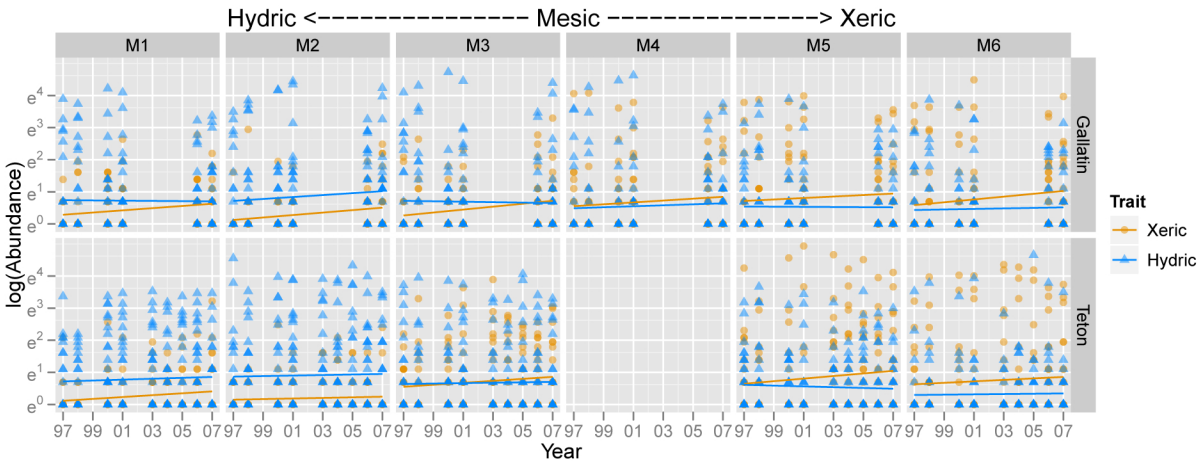

Figure B1: Observed counts and simple linear model fit separately to meadow and region.

Model

To model this data, Poisson regression (a form of a Generalized linear model) was utilized, as it is natural to assume that the response variable (count) follows the Poisson distribution. The model used can be summarized as such:

$$\begin{aligned} log_e(Y_{ijk}) &= \beta_0 + \beta_1(YEAR) + \alpha_i(REGION) + \gamma_j(MTYPE) + \delta_k(TRAIT) + \\ &\quad \beta_1\alpha_i(REGION * YEAR) + \beta_1\gamma_j(YEAR * MTYPE) + \\ &\quad \beta_1\delta_k(YEAR * TRAIT) + \gamma_j\delta_k(MTYPE * TRAIT) + \varepsilon_{ijkl} \end{aligned} \tag{B1}$$

Overall

There is a different temporal trend between regions, and the temporal trend differs between meadow types 1 and 2, 4, 5 and 6. The Tetons see a larger increase in counts by year than the

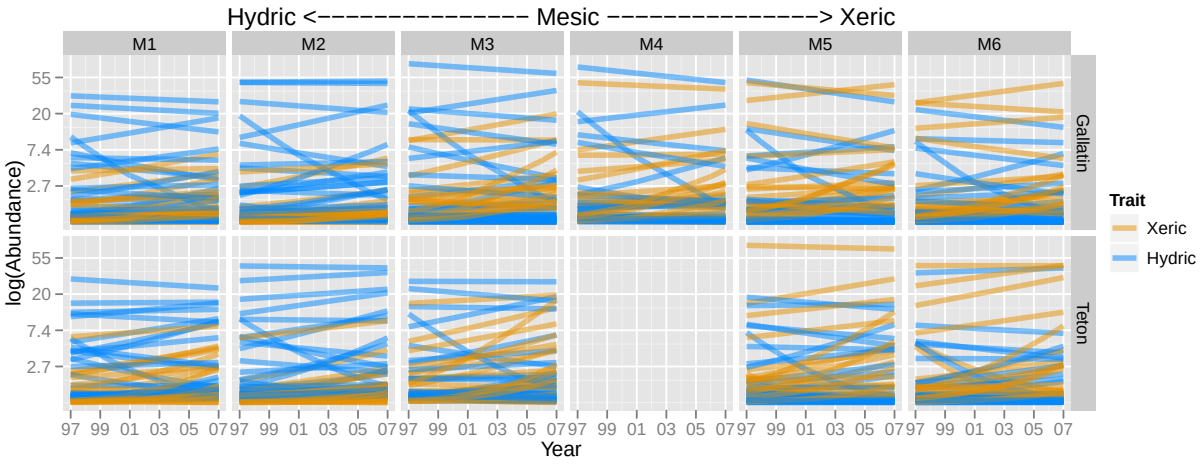

Figure B2: Observed counts for all species, with fitted random effects, on the log scale.

Table B1: Model summary

	Estimate	Std. Error	z value	P-value	Sig
(Intercept)	-0.40	0.37	-1.09	0.27	
Year	-0.01	0.03	-0.38	0.70	
RegionTeton	0.16	0.23	0.68	0.50	
MeadowM2	0.12	0.18	0.68	0.49	
MeadowM3	-0.35	0.27	-1.31	0.19	
MeadowM4	-0.56	0.36	-1.57	0.12	
MeadowM5	-1.04	0.40	-2.60	0.01	**
MeadowM6	-1.45	0.42	-3.44	0.00	***
TraitXeric	-1.69	0.54	-3.10	0.00	**
Year:RegionTeton	0.03	0.01	4.54	0.00	***
Year:MeadowM2	0.02	0.01	2.31	0.02	*
Year:MeadowM3	-0.01	0.01	-1.10	0.27	
Year:MeadowM4	-0.03	0.01	-2.28	0.02	*
Year:MeadowM5	-0.04	0.01	-4.56	0.00	***
Year:MeadowM6	-0.03	0.01	-3.32	0.00	***
Year:TraitXeric	0.08	0.04	2.04	0.04	*
MeadowM2:TraitXeric	-0.69	0.29	-2.41	0.02	*
MeadowM3:TraitXeric	1.27	0.40	3.19	0.00	**
MeadowM4:TraitXeric	1.90	0.55	3.47	0.00	***
MeadowM5:TraitXeric	2.73	0.61	4.48	0.00	***
MeadowM6:TraitXeric	3.01	0.64	4.70	0.00	***

Table B2: Model fit statistics

AIC	BIC	logLik	deviance	R^2	Fixed Eff R^2	N	Num Species
11268	11628	-5577	11154	0.97	0.04	4131	51

Gallatins. In M2 the trend is increasing but in M4, M5, M6 the trend is decreasing. Xeric species show an increasing trend.

The plots of individual species over the next several pages are ordered from highest positive random effects slope to highest negative slope, effectively from most overall increasing trend to most decreasing trend in abundance.

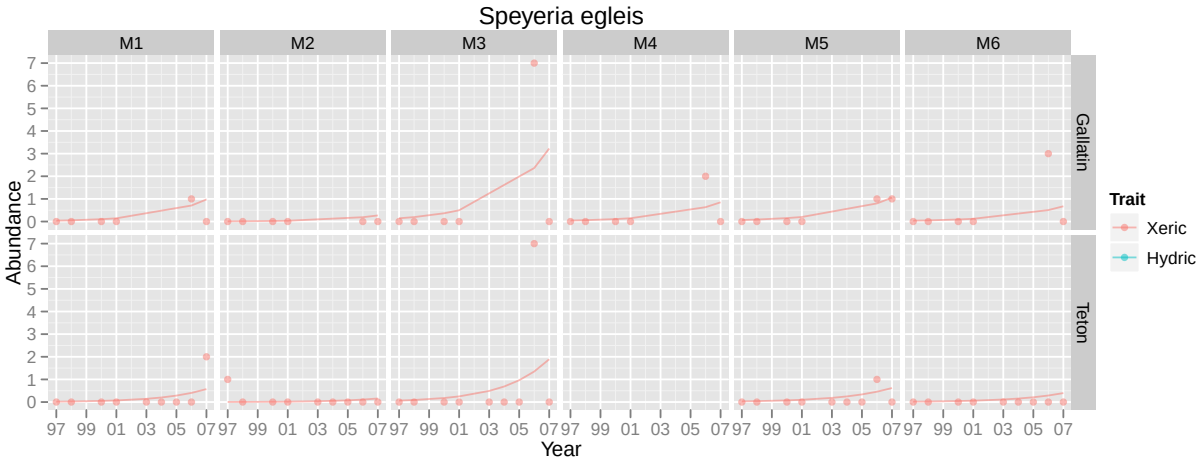

Figure B3: Observed counts and fitted model for Speyeria egleis.

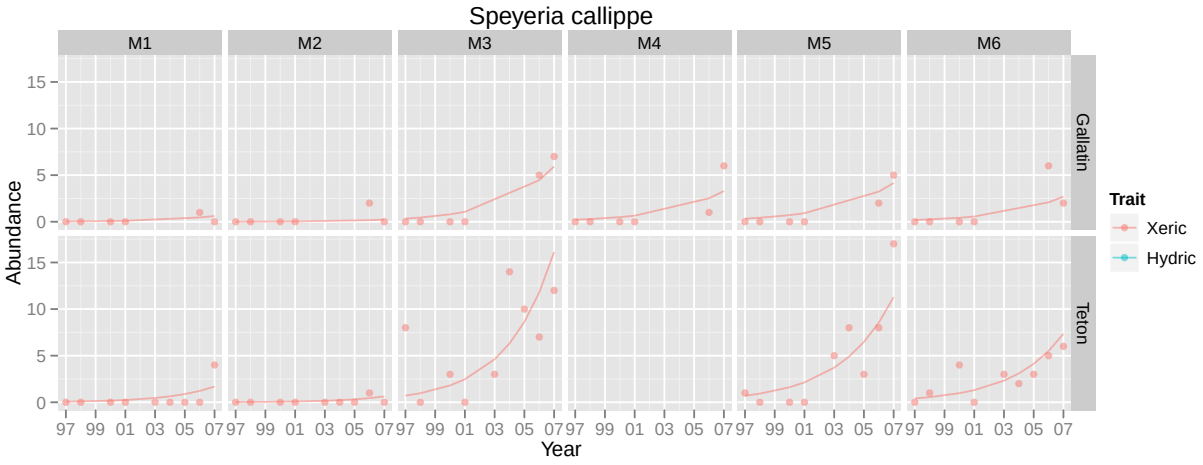

Figure B4: Observed counts and fitted model for Speyeria callippe.

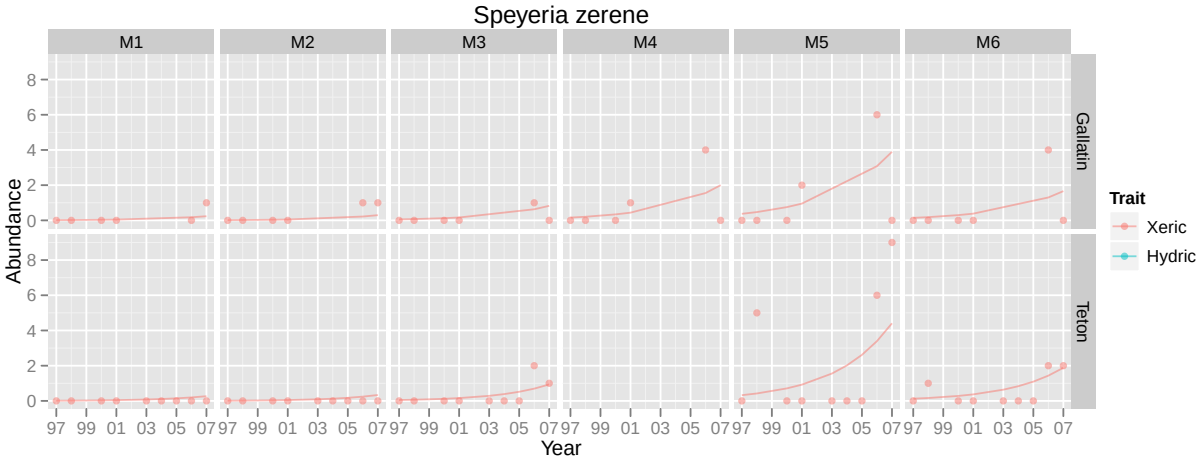

Figure B5: Observed counts and fitted model for Speyeria zerene.

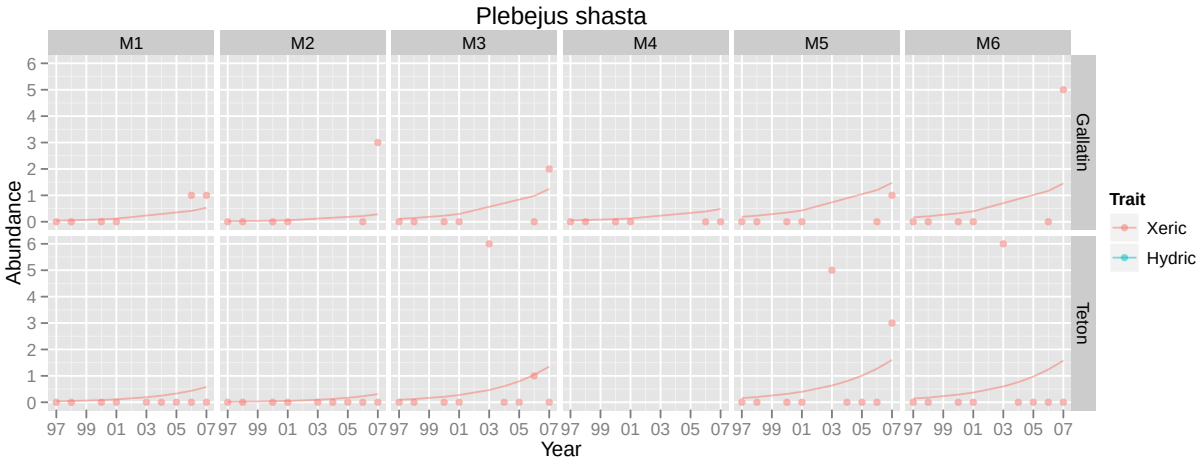

Figure B6: Observed counts and fitted model for Plebejus shasta.

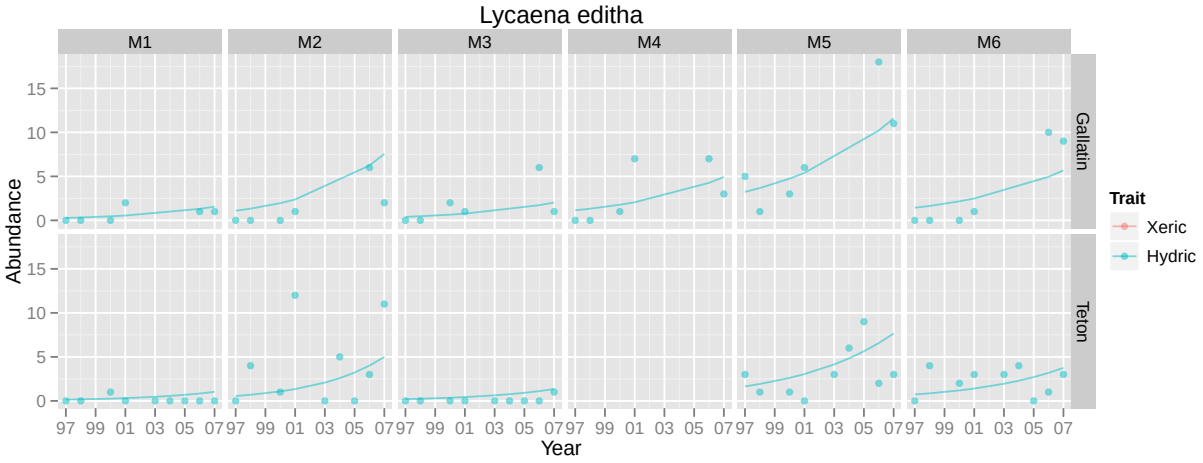

Figure B7: Observed counts and fitted model for Lycaena editha.

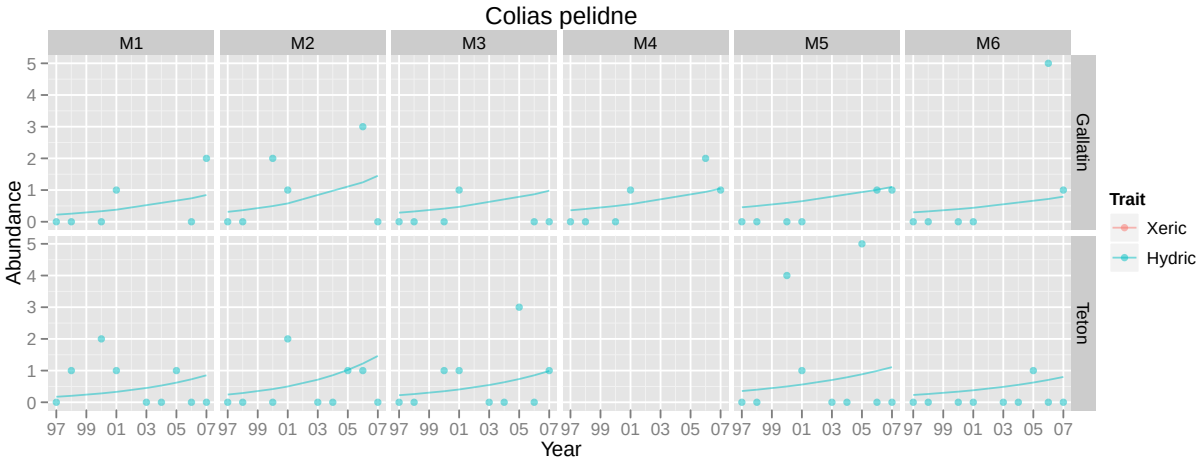

Figure B8: Observed counts and fitted model for Colias pelidne.

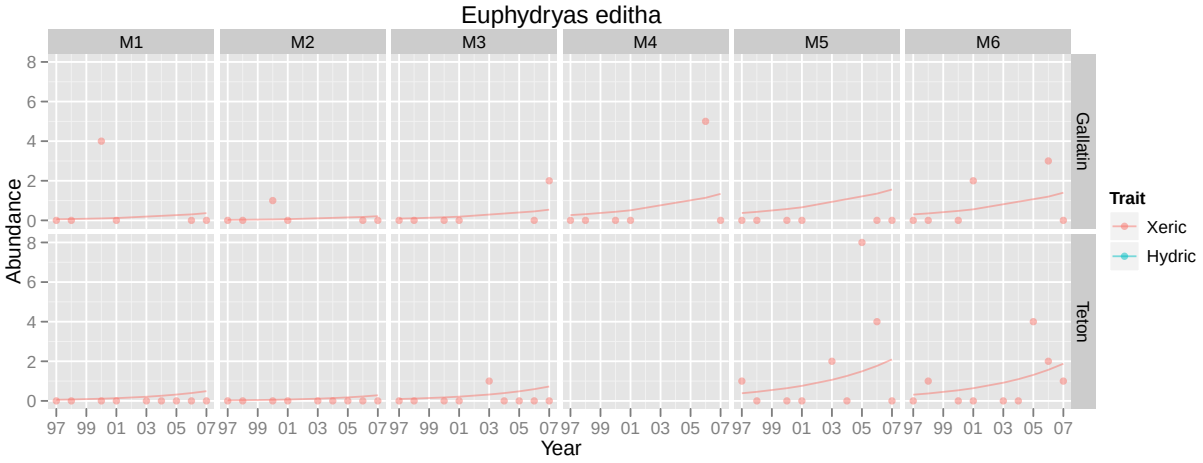

Figure B9: Observed counts and fitted model for Euphydryas editha.

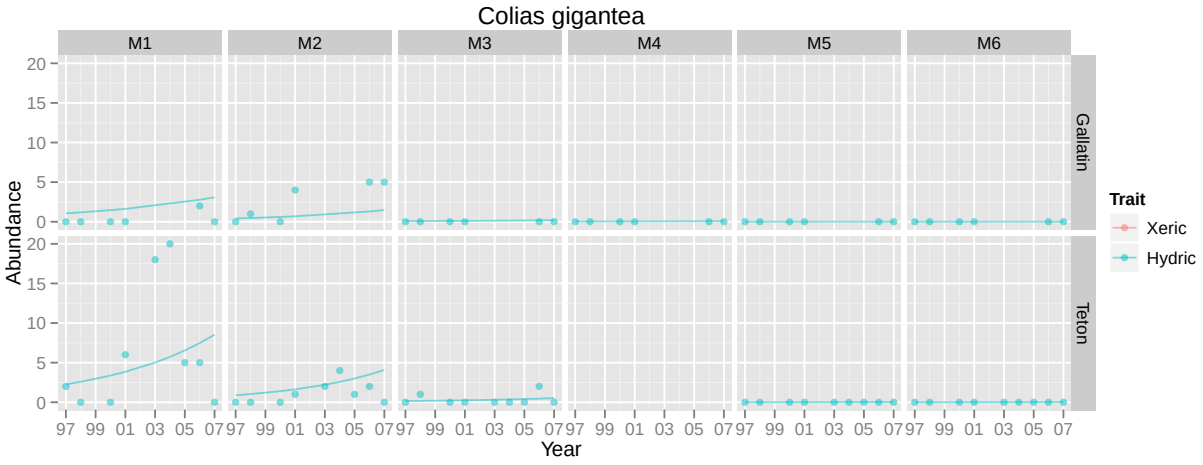

Figure B10: Observed counts and fitted model for Colias gigantea.

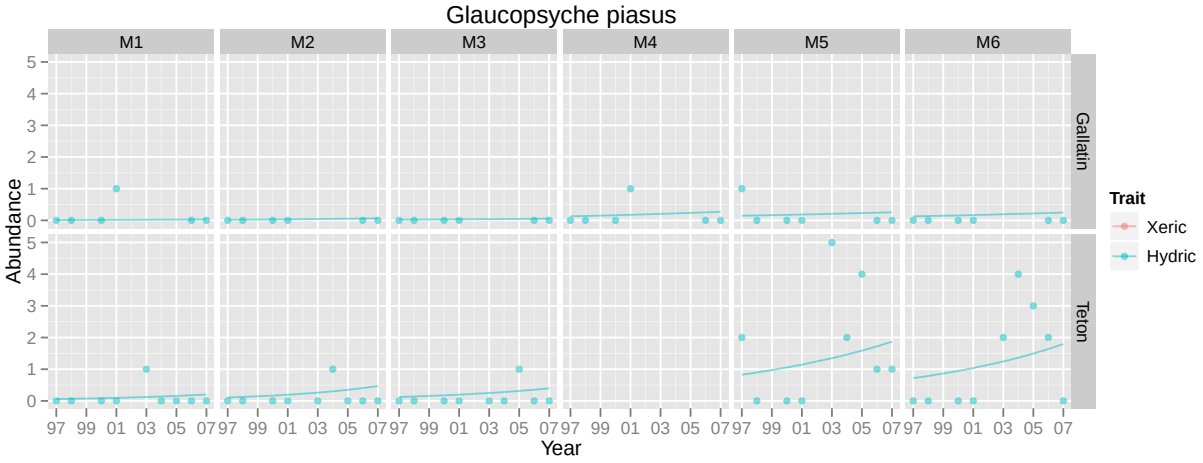

Figure B11: Observed counts and fitted model for Glaucopsyche piasus.

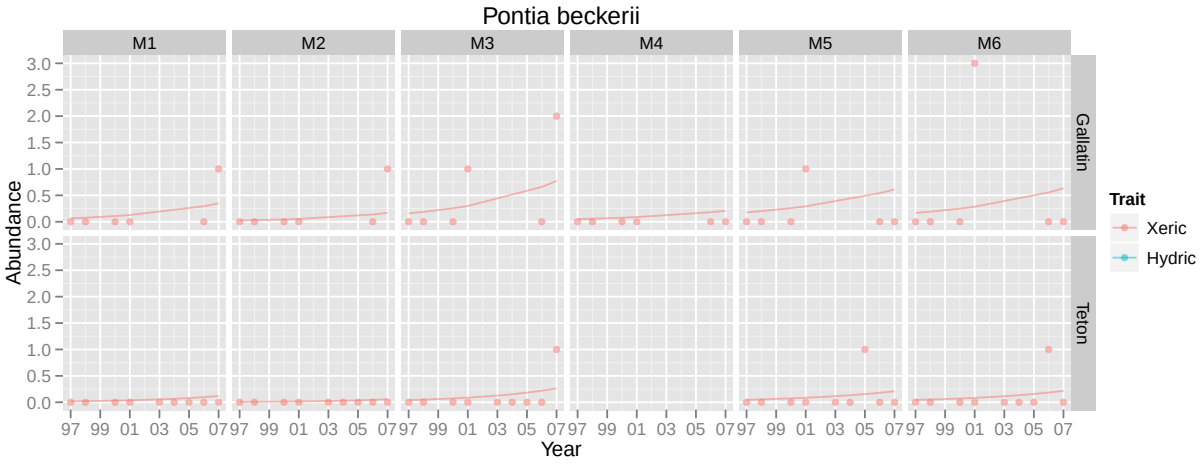

Figure B12: Observed counts and fitted model for Pontia beckerii.

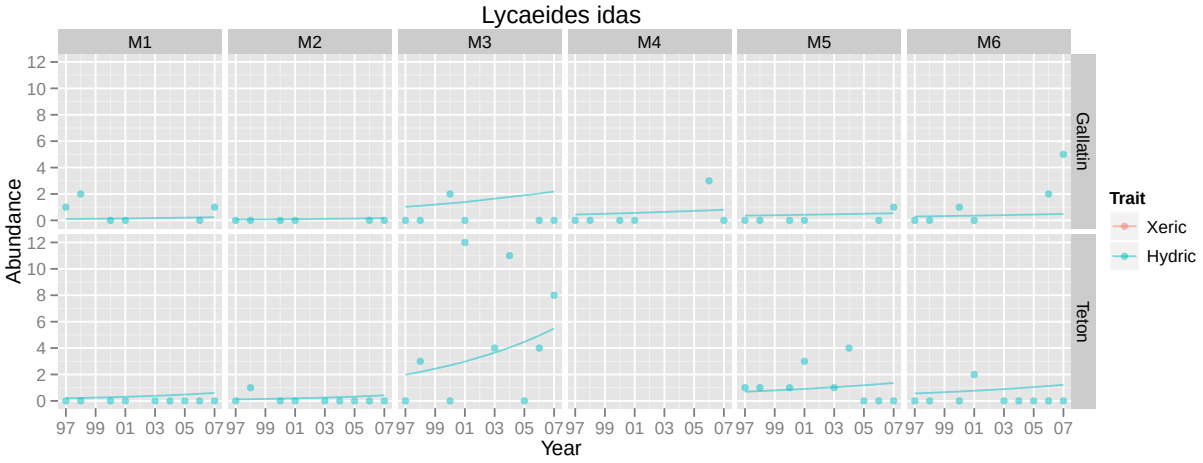

Figure B13: Observed counts and fitted model for Lycaeides idas.

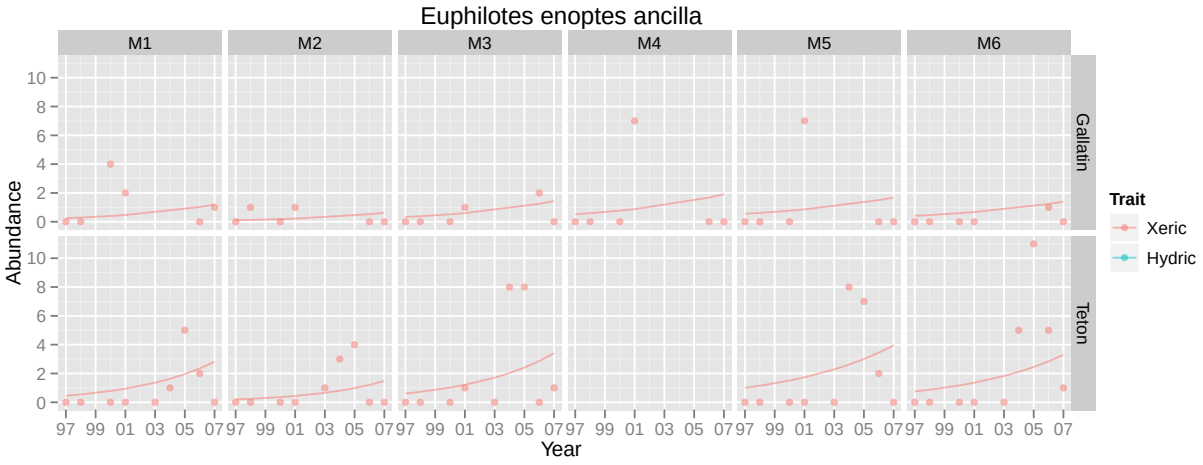

Figure B14: Observed counts and fitted model for Euphilotes enoptes ancilla.

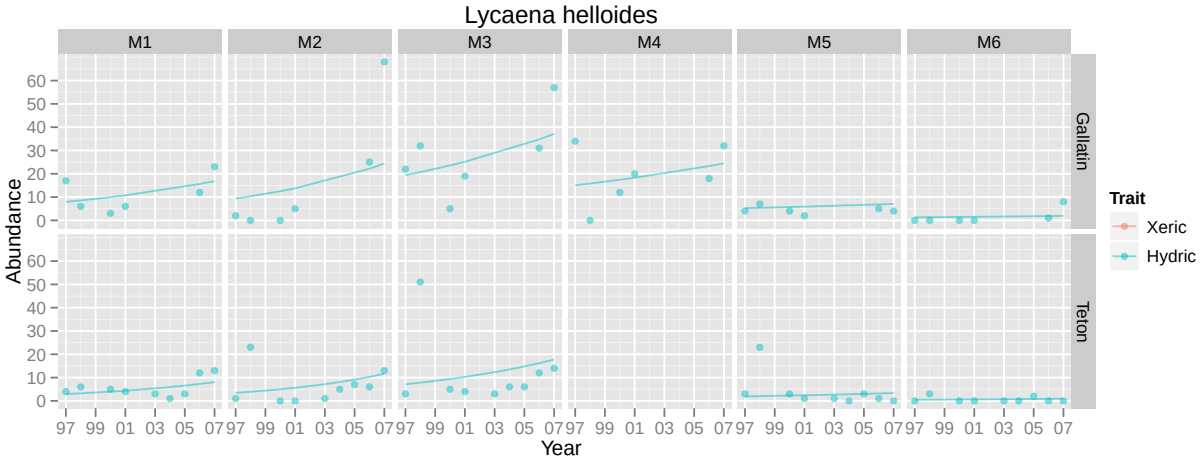

Figure B15: Observed counts and fitted model for Lycaena helloides.

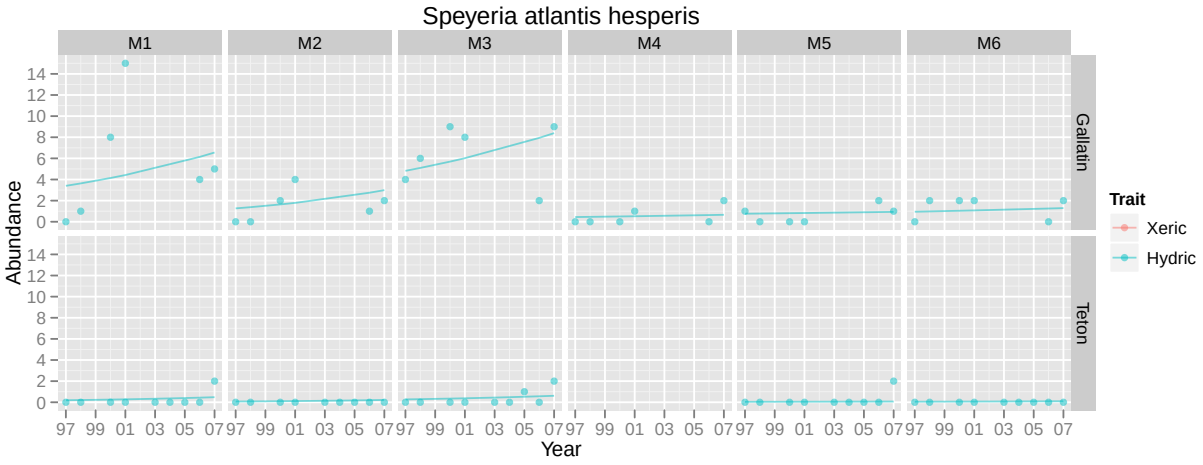

Figure B16: Observed counts and fitted model for Speyeria atlantis hesperis.

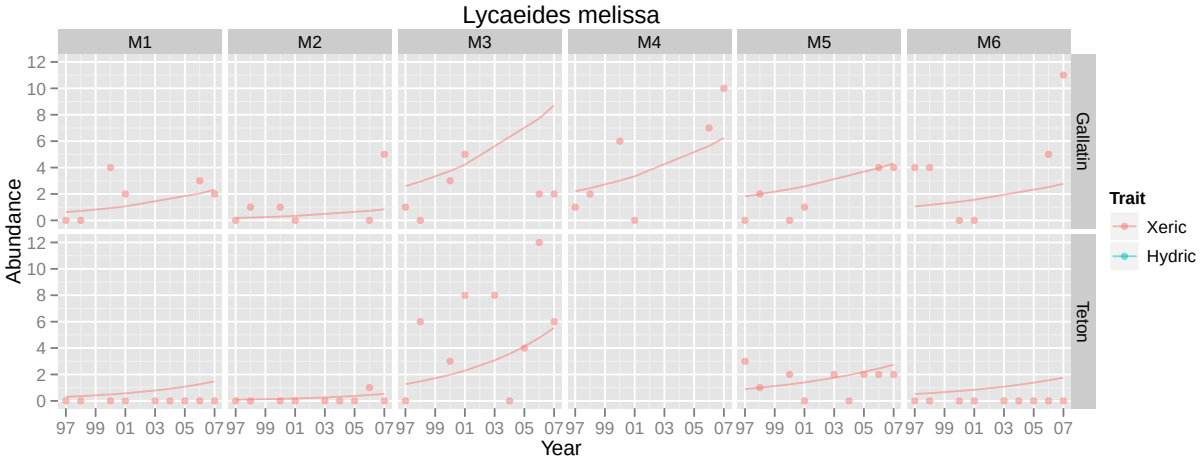

Figure B17: Observed counts and fitted model for Lycaeides melissa.

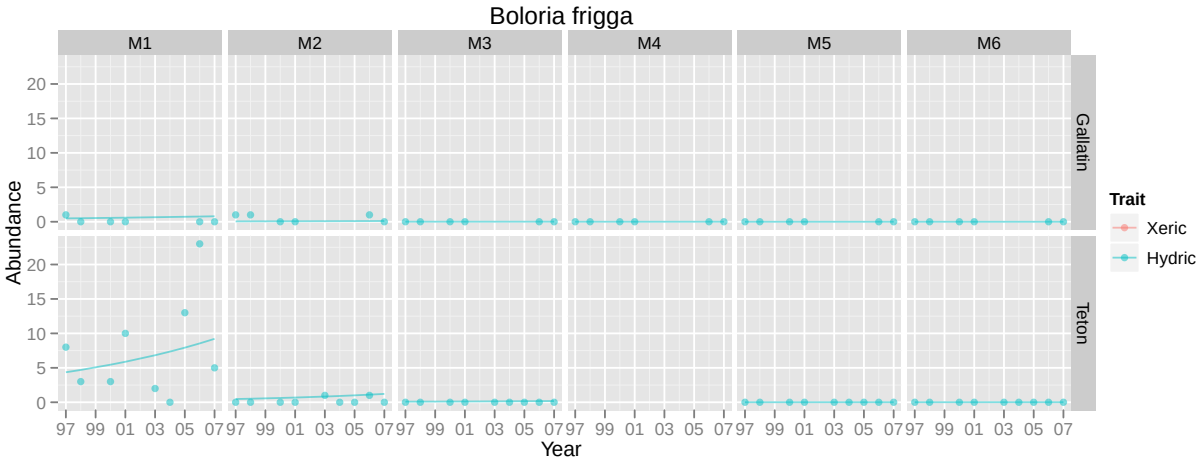

Figure B18: Observed counts and fitted model for Boloria frigga.

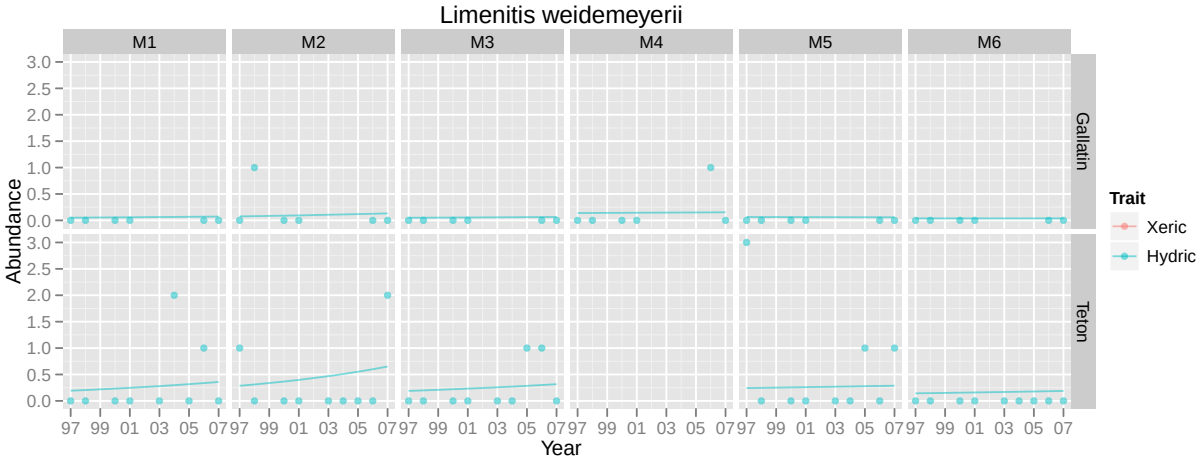

Figure B19: Observed counts and fitted model for Limenitis weidemeyerii.

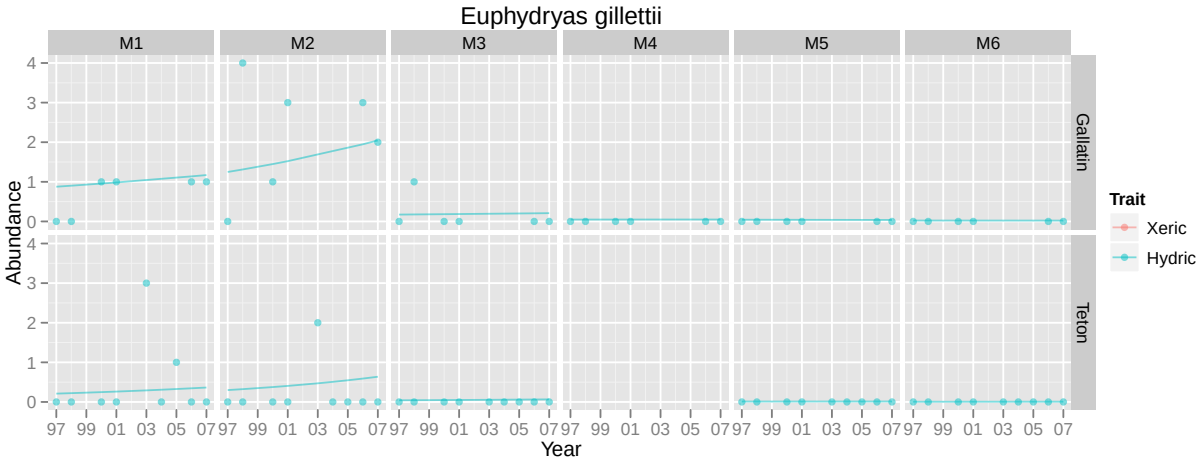

Figure B20: Observed counts and fitted model for Euphydryas gillettii.

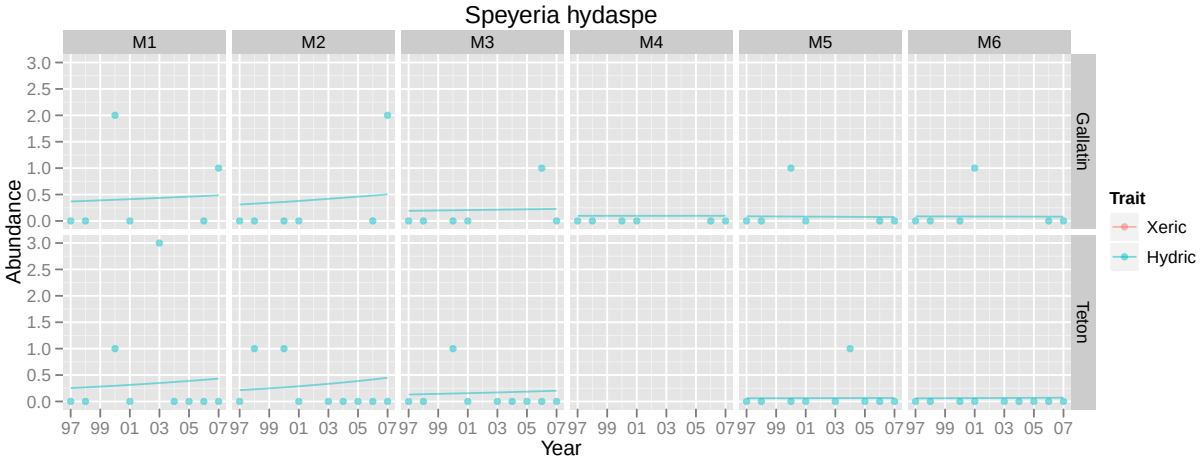

Figure B21: Observed counts and fitted model for Speyeria hydaspe.

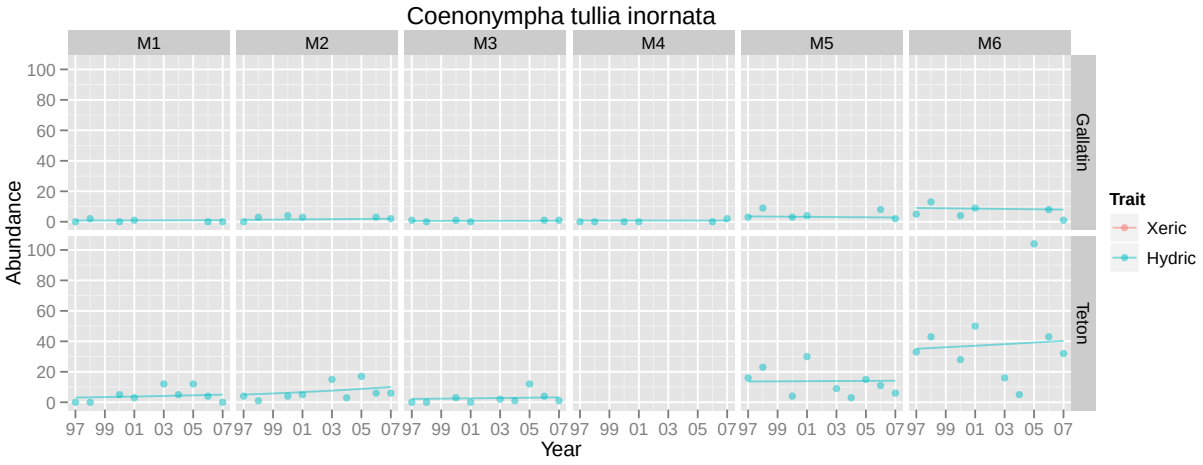

Figure B22: Observed counts and fitted model for Coenonympha tullia inornata.

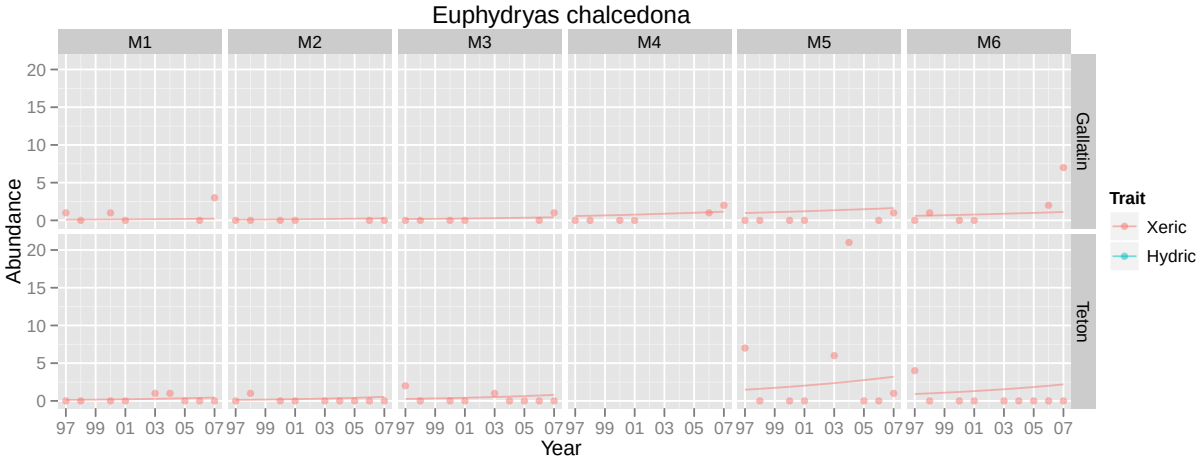

Figure B23: Observed counts and fitted model for Euphydryas chalcedona.

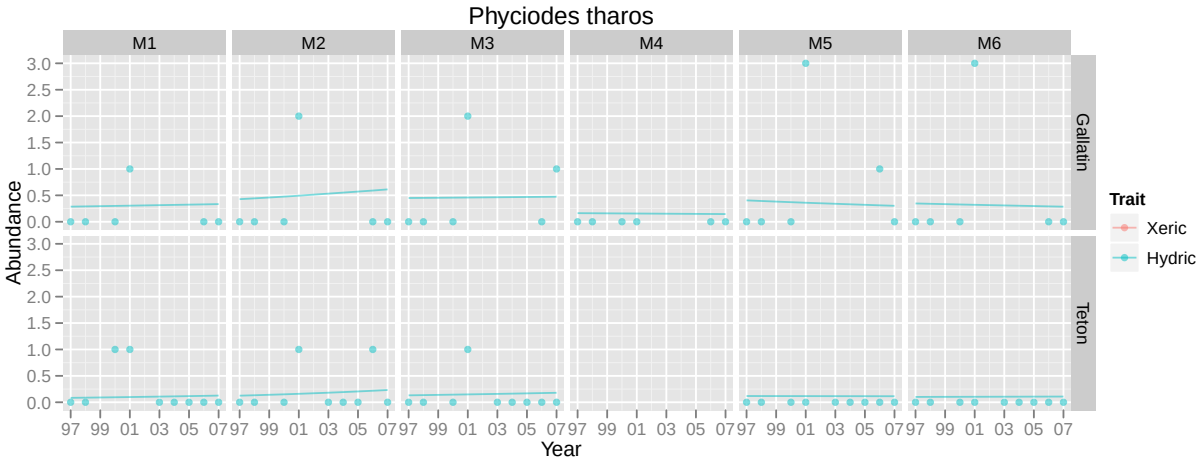

Figure B24: Observed counts and fitted model for Phyciodes tharos.

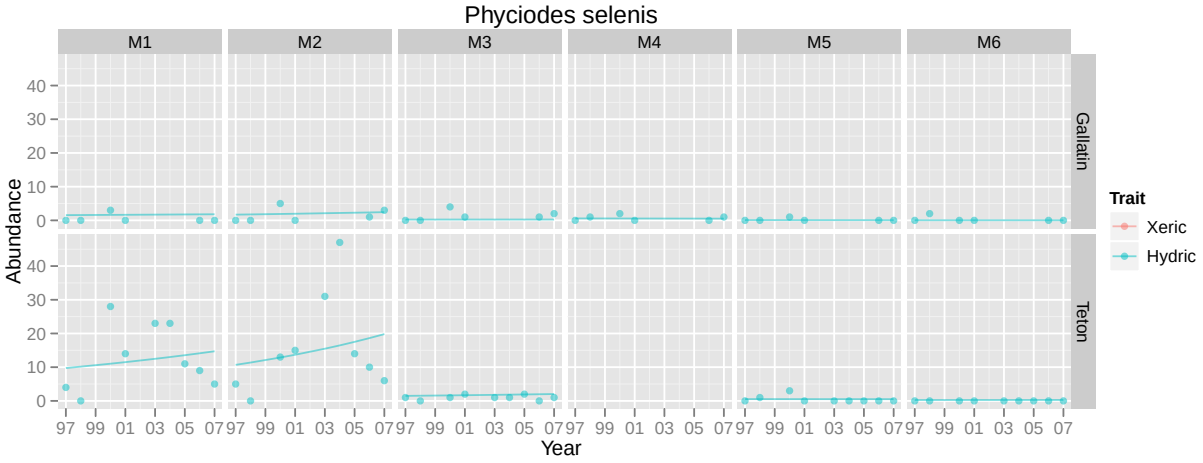

Figure B25: Observed counts and fitted model for Phyciodes selenis.

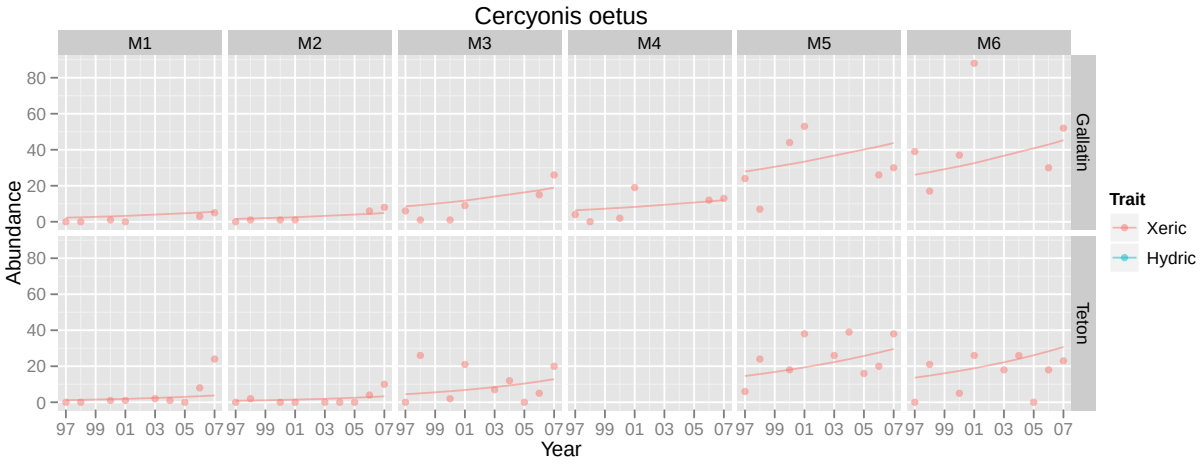

Figure B26: Observed counts and fitted model for Cercyonis oetus.

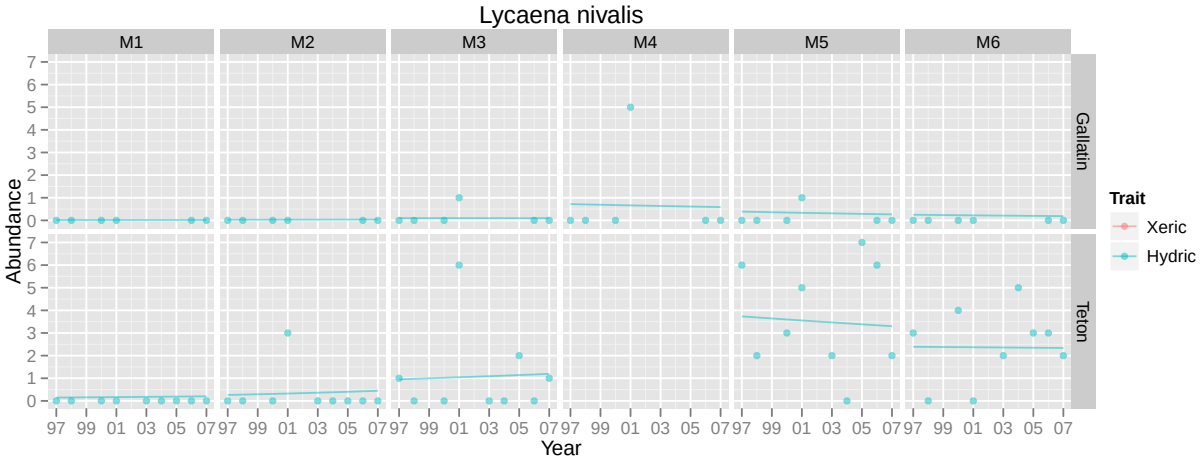

Figure B27: Observed counts and fitted model for Lycaena nivalis.

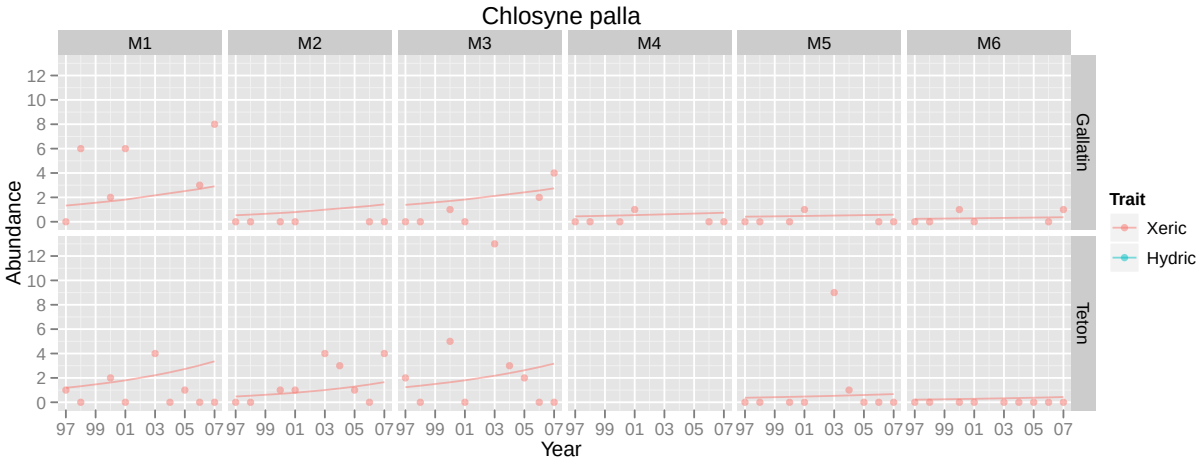

Figure B28: Observed counts and fitted model for Chlosyne palla.

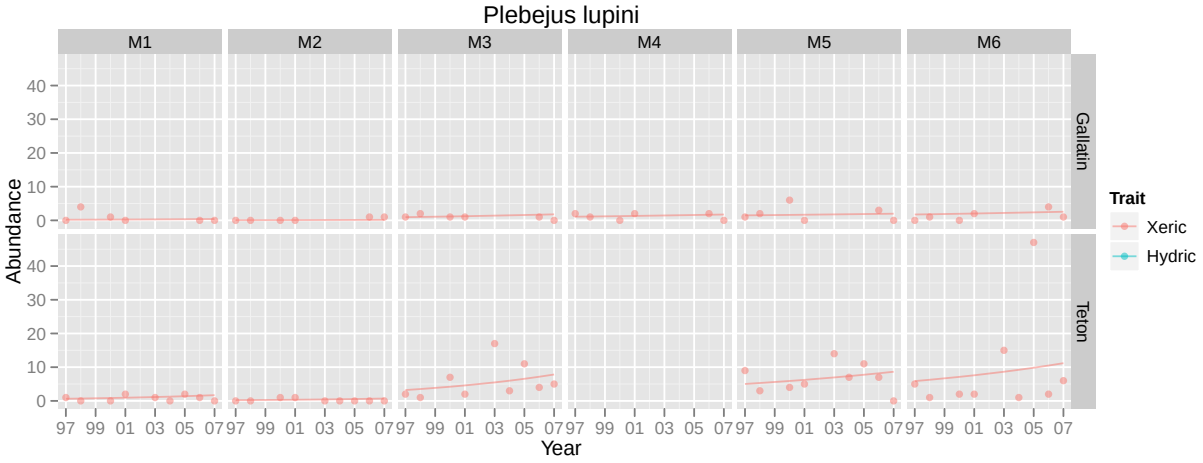

Figure B29: Observed counts and fitted model for Plebejus lupini.

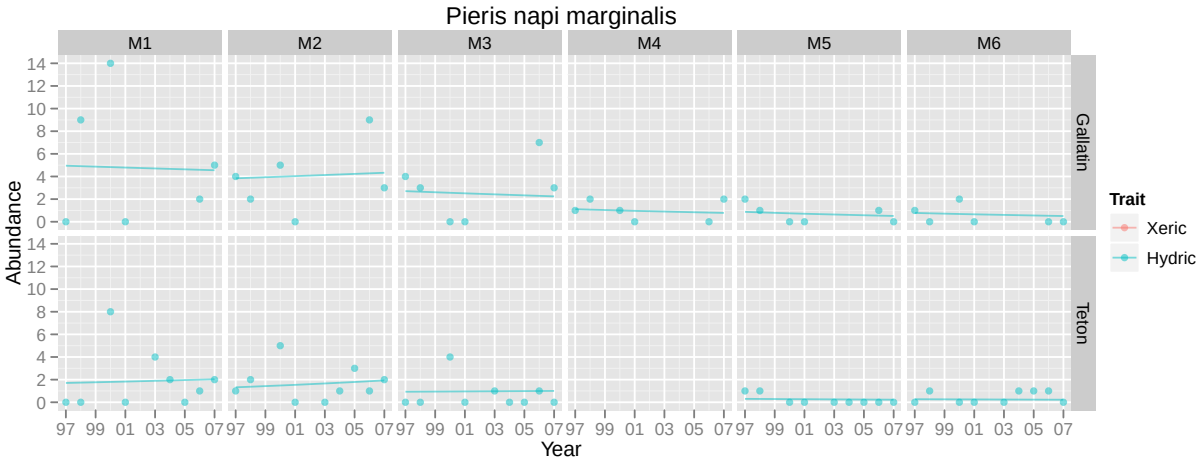

Figure B30: Observed counts and fitted model for Pieris napi marginalis.

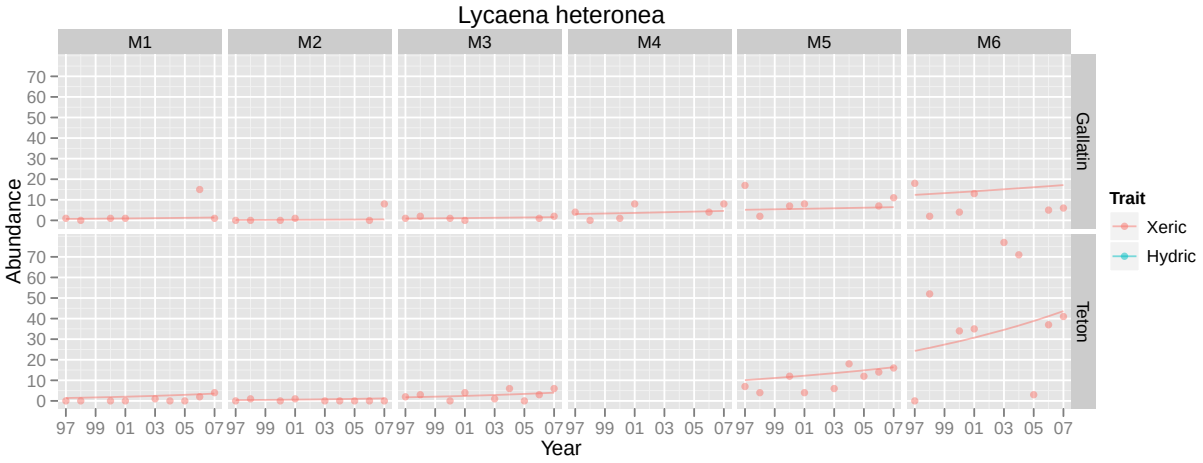

Figure B31: Observed counts and fitted model for Lycaena heteronea.

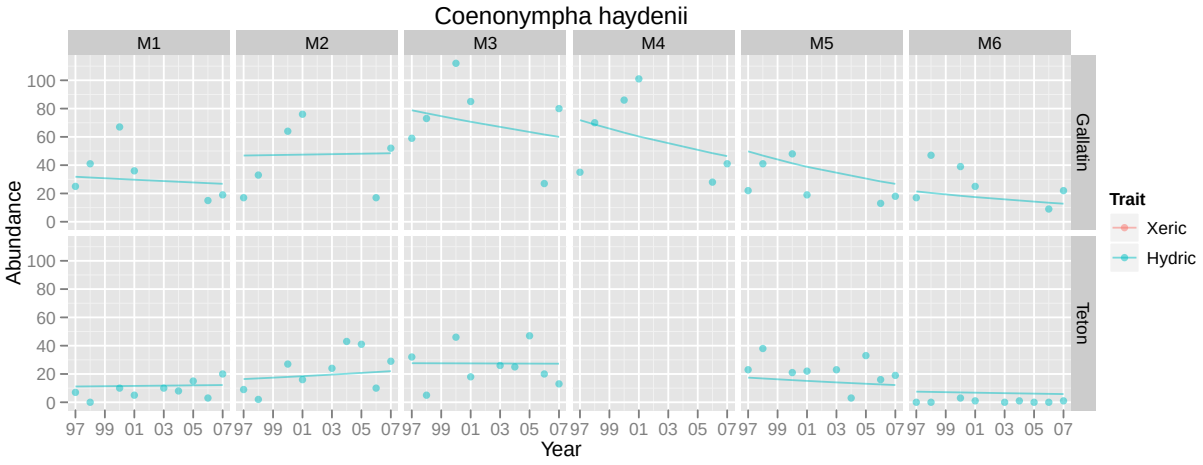

Figure B32: Observed counts and fitted model for Coenonympha haydenii.

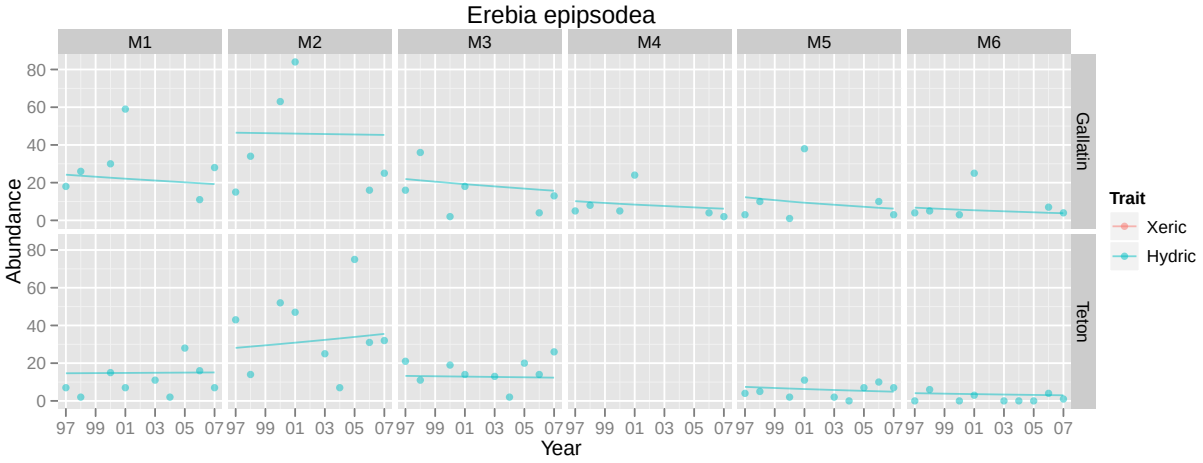

Figure B33: Observed counts and fitted model for Erebia epipsodea.

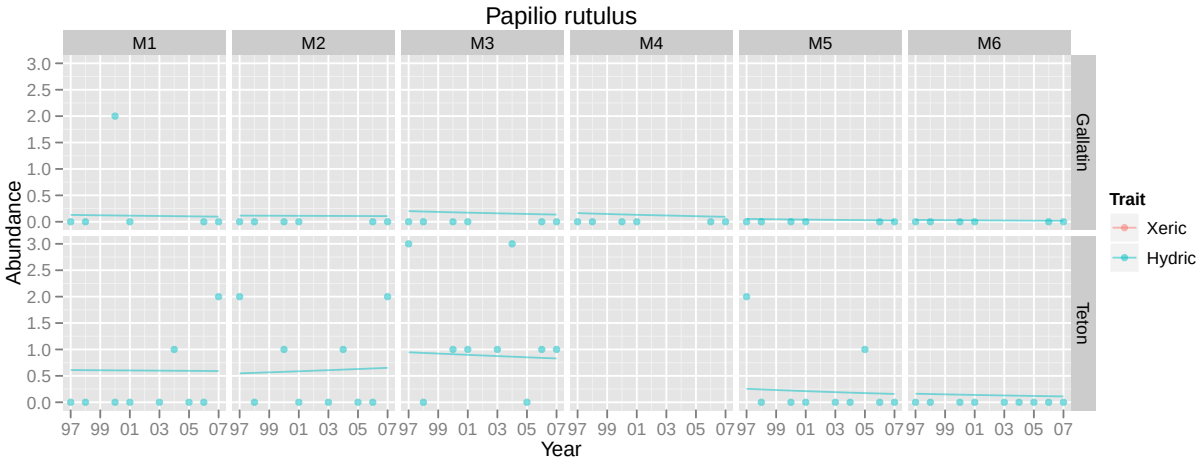

Figure B34: Observed counts and fitted model for Papilio rutulus.

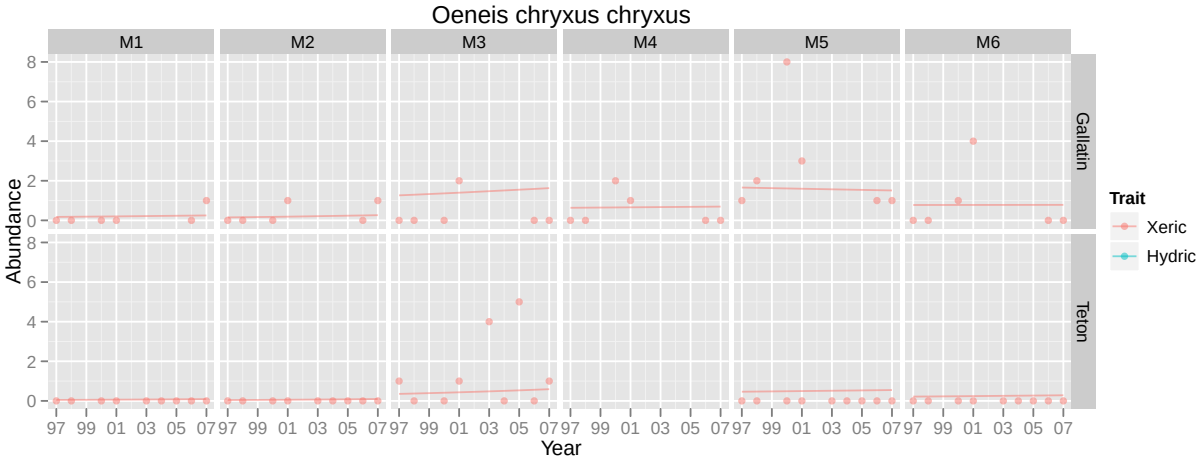

Figure B35: Observed counts and fitted model for Oeneis chryxus chryxus.

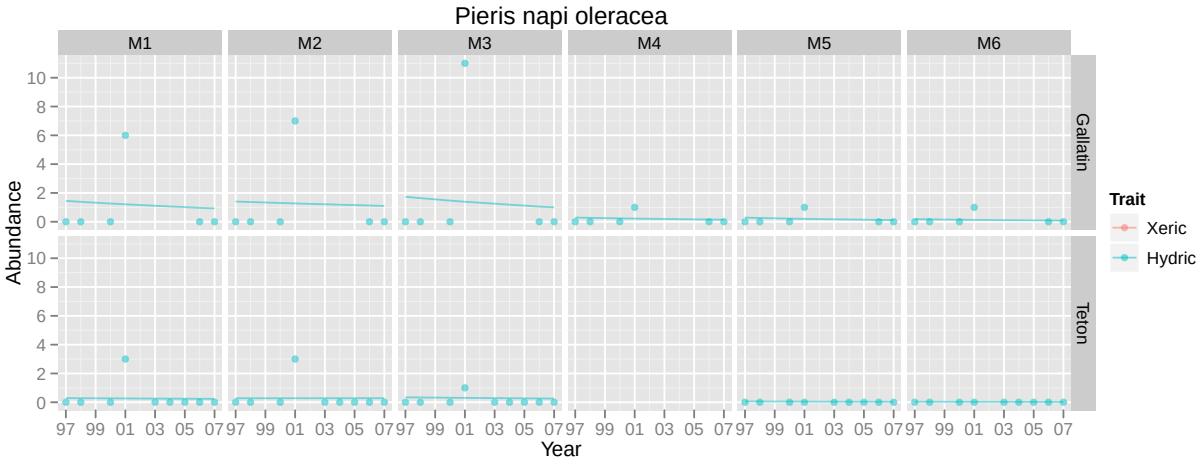

Figure B36: Observed counts and fitted model for Pieris napi oleracea.

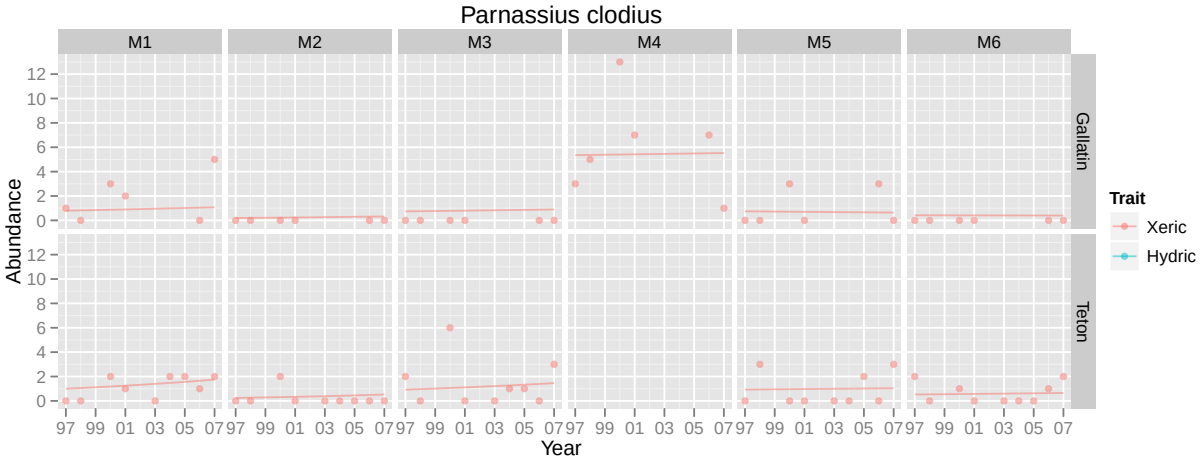

Figure B37: Observed counts and fitted model for Parnassius clodius.

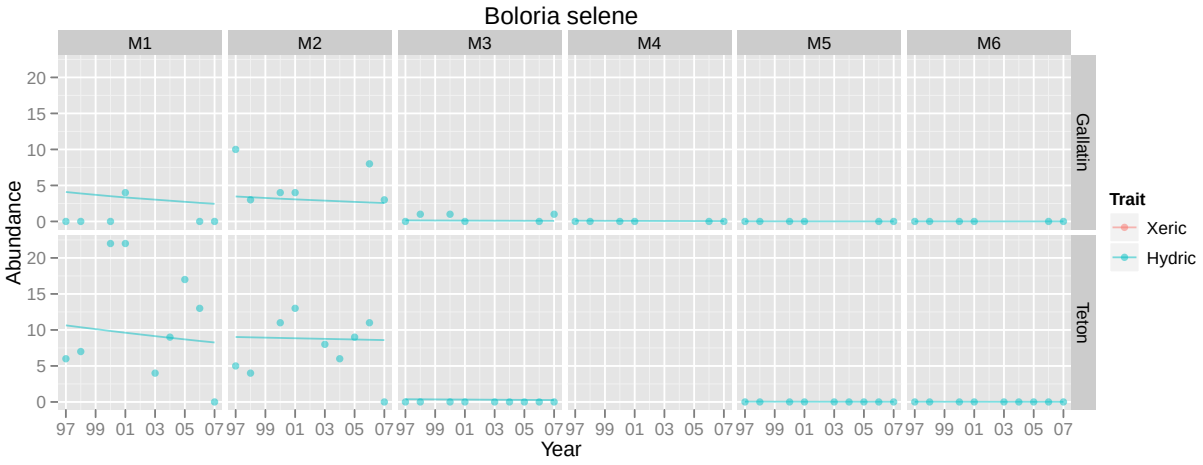

Figure B38: Observed counts and fitted model for Boloria selene.

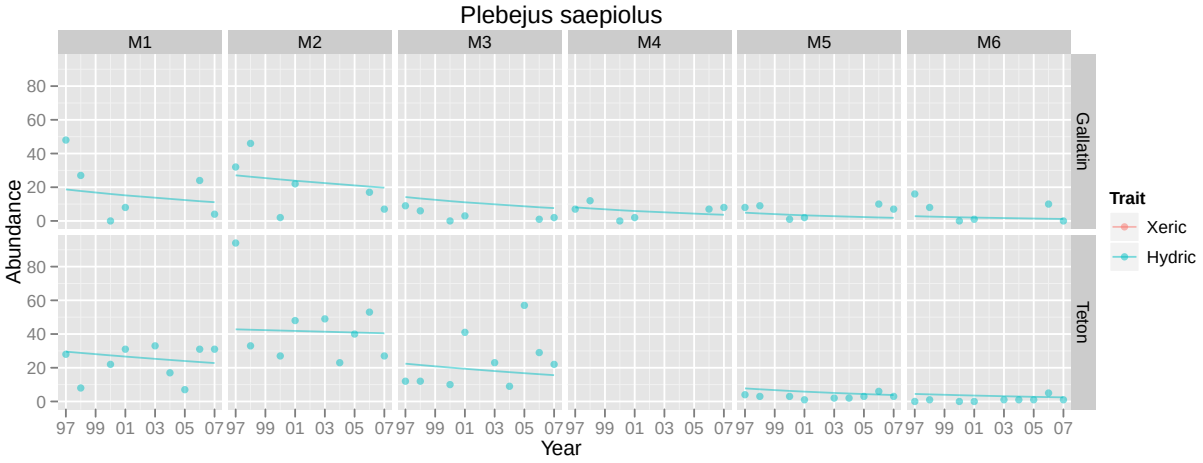

Figure B39: Observed counts and fitted model for Plebejus saepiolus.

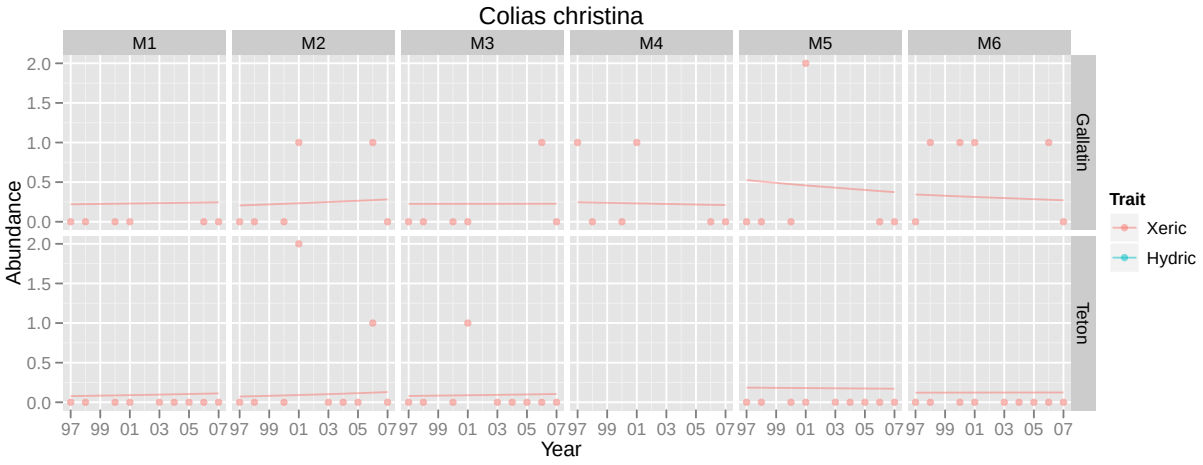

Figure B40: Observed counts and fitted model for Colias christina.

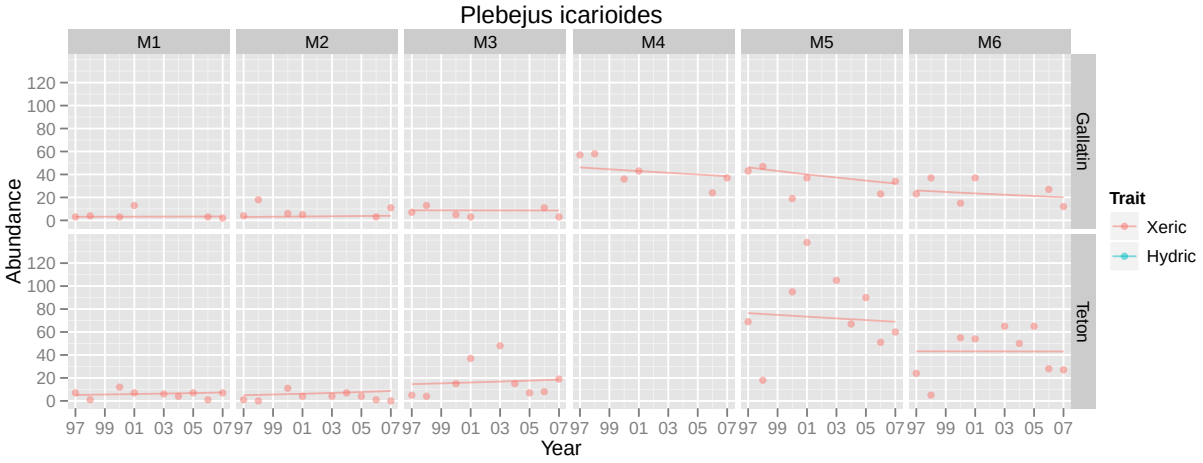

Figure B41: Observed counts and fitted model for Plebejus icarioides.

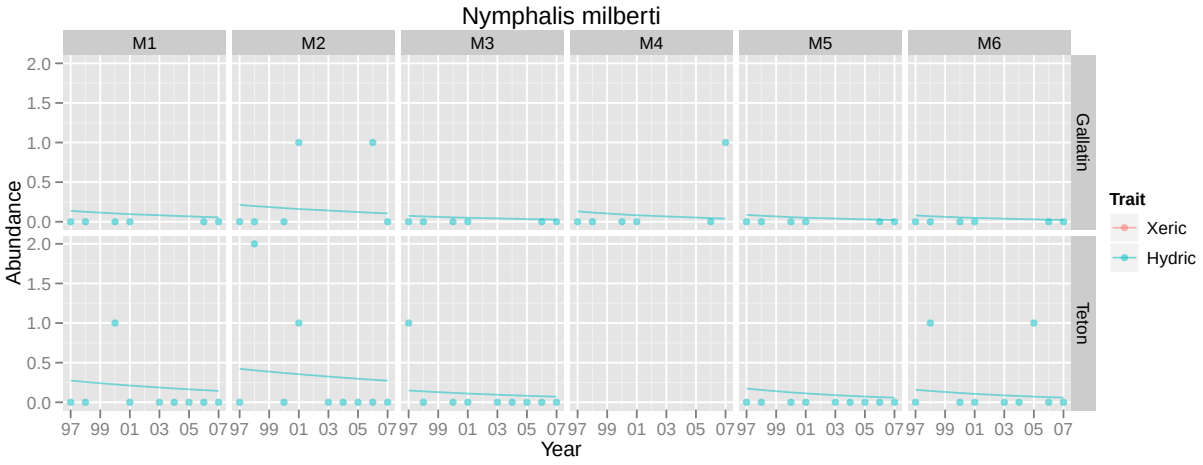

Figure B42: Observed counts and fitted model for Nymphalis milberti.

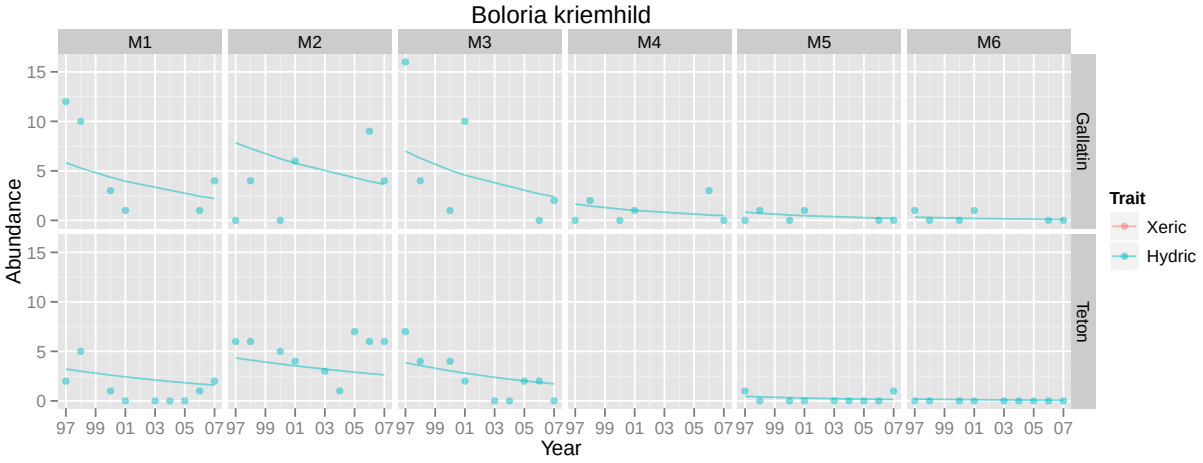

Figure B43: Observed counts and fitted model for Boloria kriemhild.

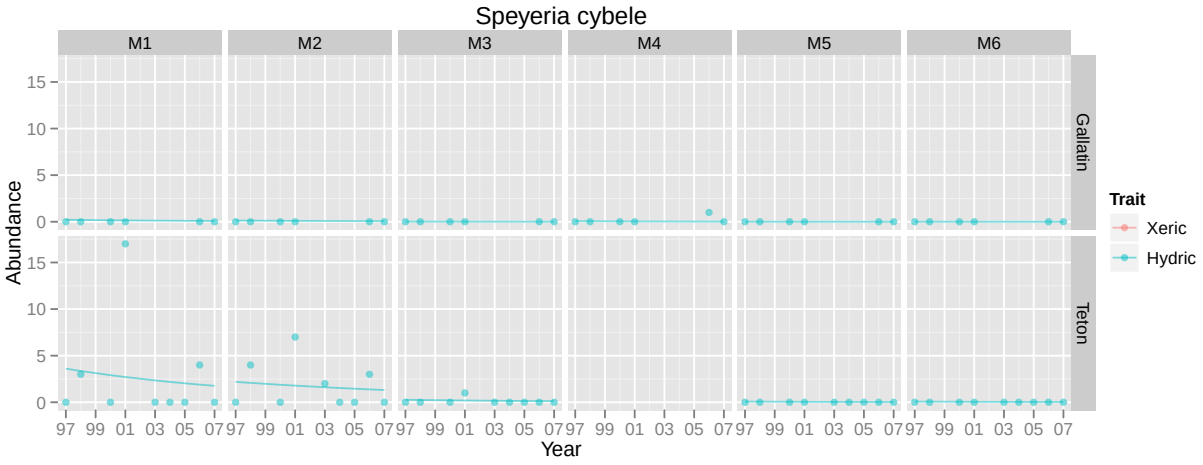

Figure B44: Observed counts and fitted model for Speyeria cybele.

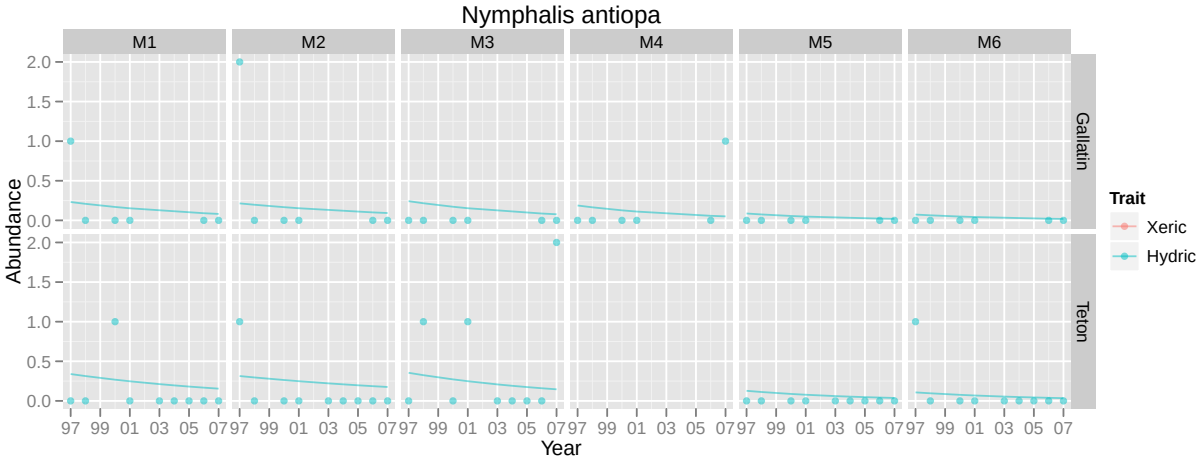

Figure B45: Observed counts and fitted model for Nymphalis antiopa.

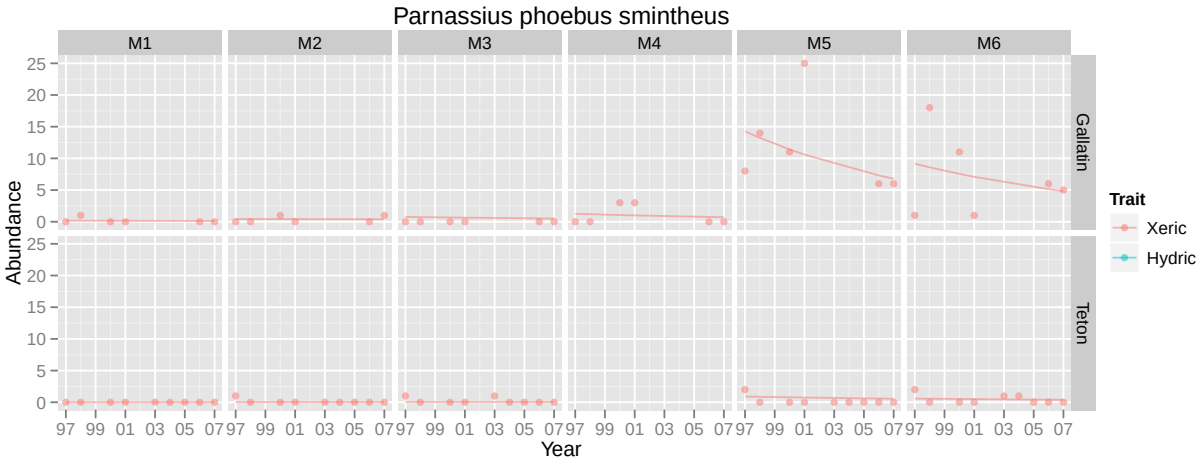

Figure B46: Observed counts and fitted model for Parnassius phoebus smintheus.

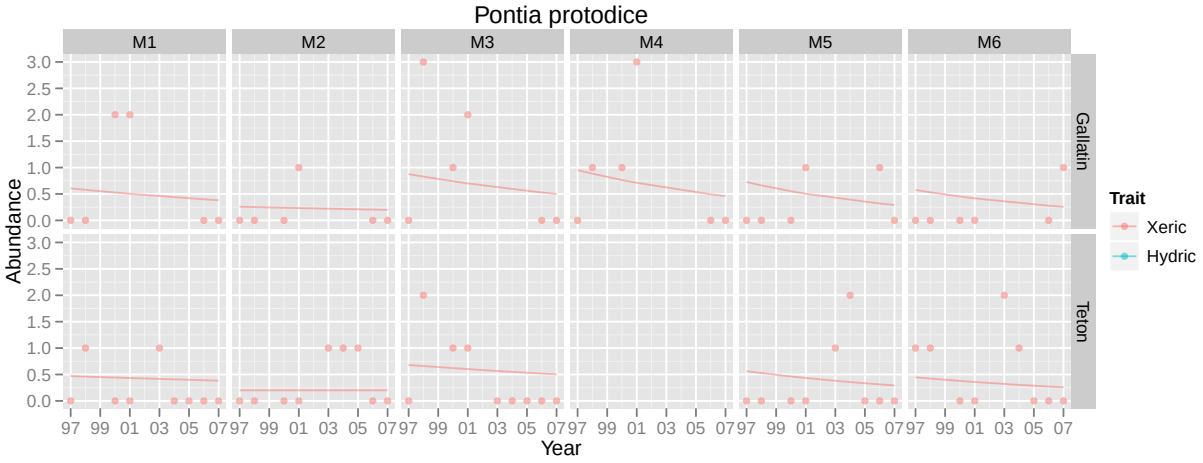

Figure B47: Observed counts and fitted model for Pontia protodice.

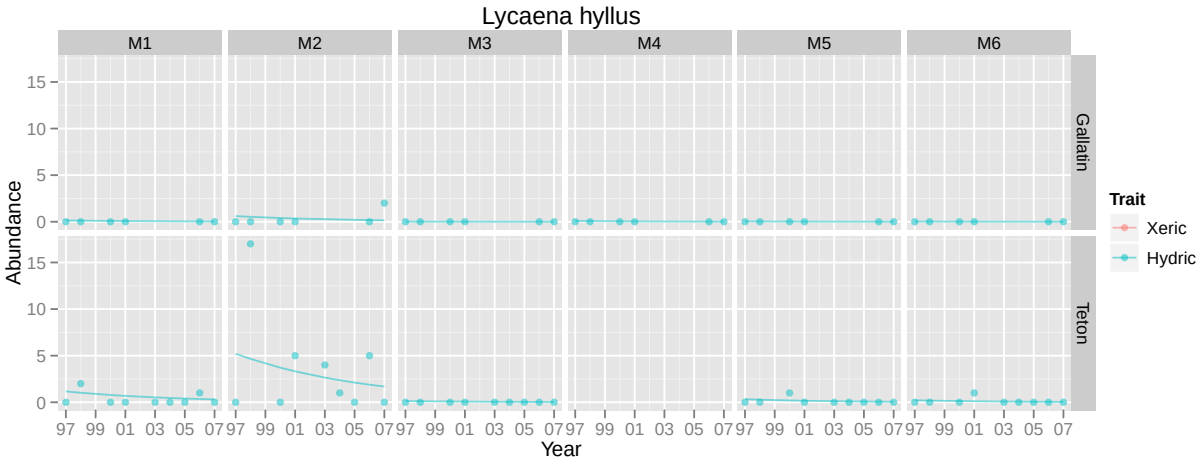

Figure B48: Observed counts and fitted model for Lycaena hyllus.

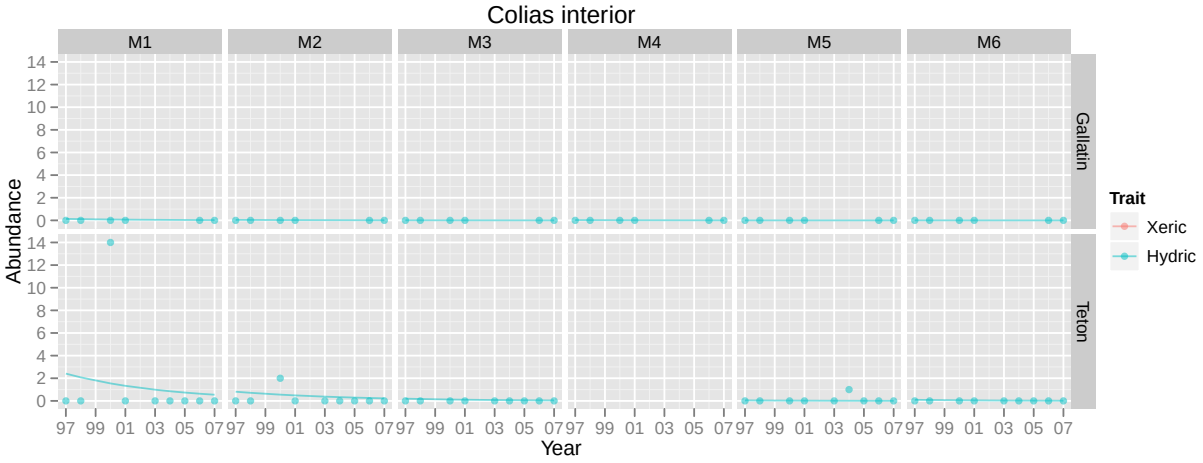

Figure B49: Observed counts and fitted model for Colias interior.

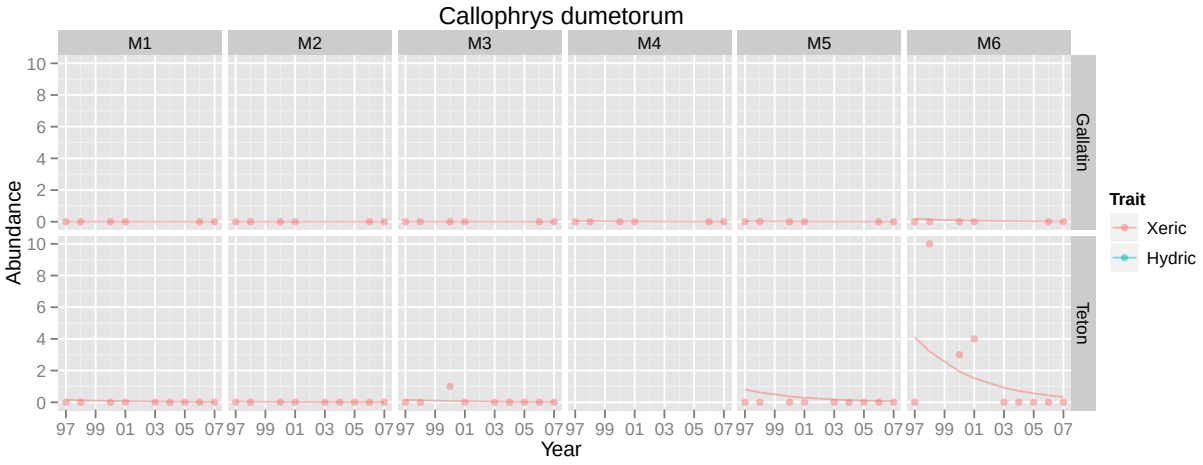

Figure B50: Observed counts and fitted model for Callophrys dumetorum.

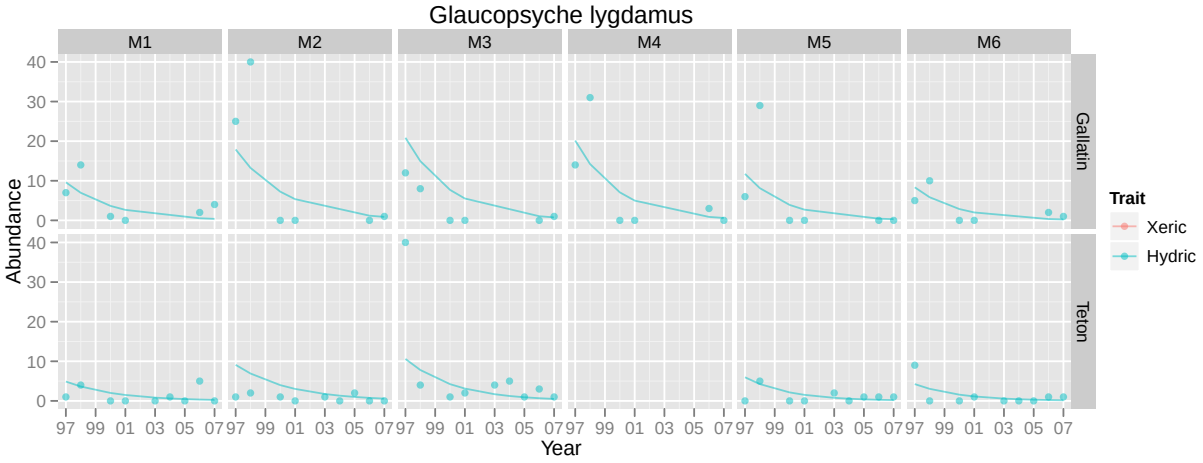

Figure B51: Observed counts and fitted model for Glaucopsyche lygdamus.

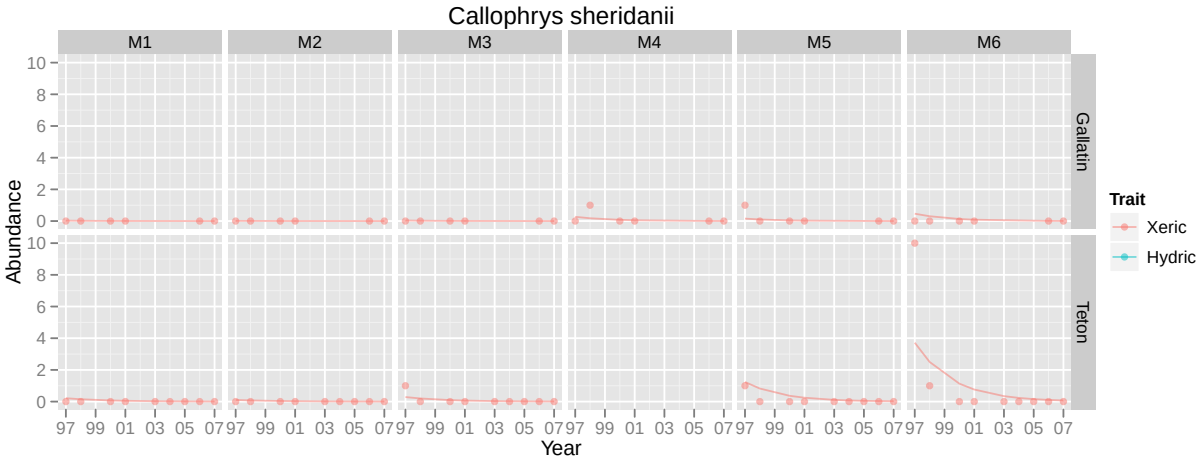

Figure B52: Observed counts and fitted model for Callophrys sheridanii.