

Review of Water Thresholds - Gnangara

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Introduction

This report details an analysis that reviews the ecological impacts of revised proposed water level thresholds for wetlands in the Gnangara mound.

Full analysis can be found at (<https://github.com/ChrisKav/DWER-Thresholds-2019>)

EMP 173

Five year summaries of surface water level data at
EMP 173

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	51.122	50.209	0.913	October	March	195.667
08/1999 - 07/2004	51.086	50.410	0.676	September	April	157.600
08/2004 - 07/2009	51.036	50.410	0.626	August	January	79.000
08/2009 - 07/2014	50.732	50.400	0.332	October	February	60.800
08/2014 - 07/2019	50.804	50.400	0.404	September	January	85.600

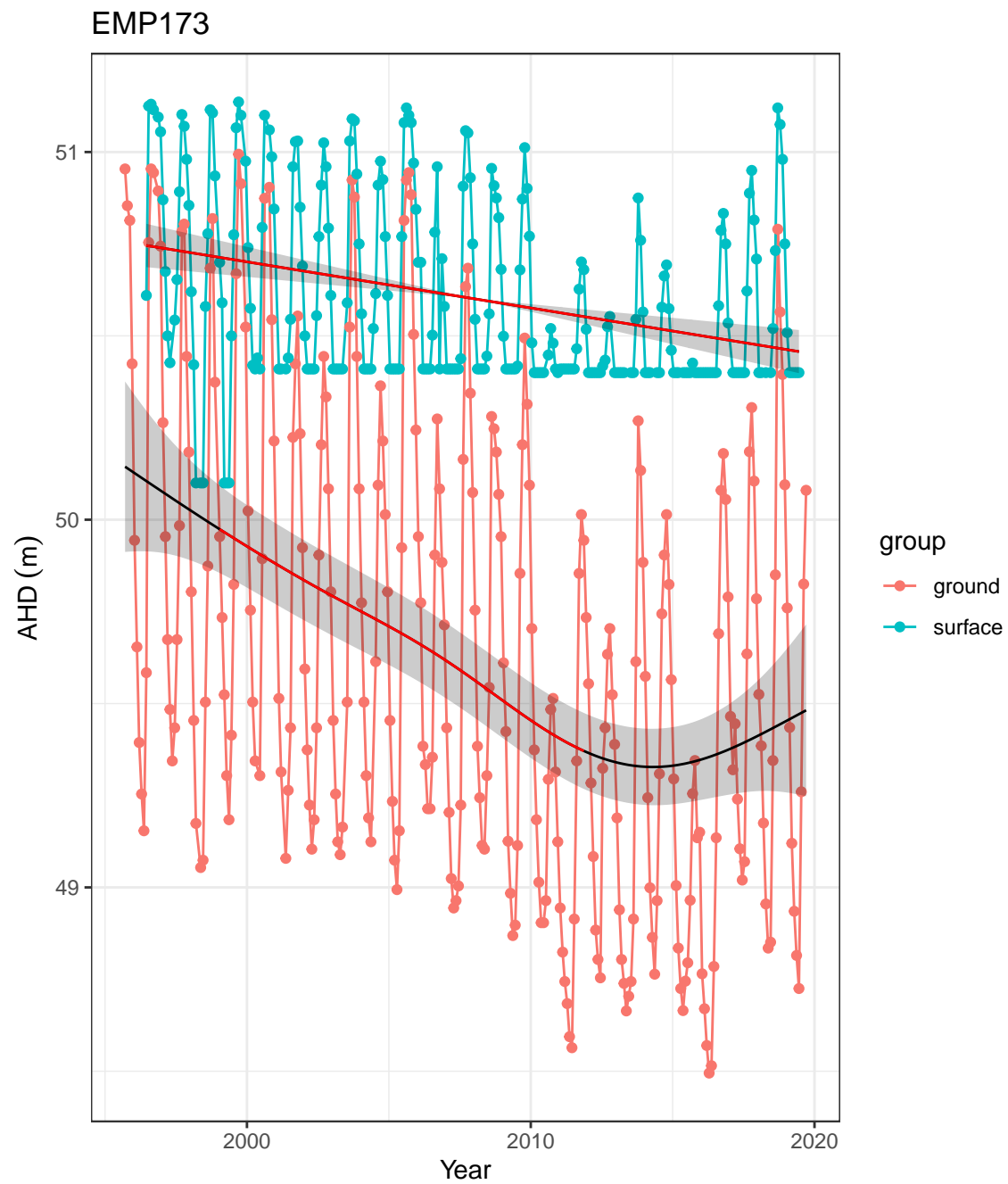
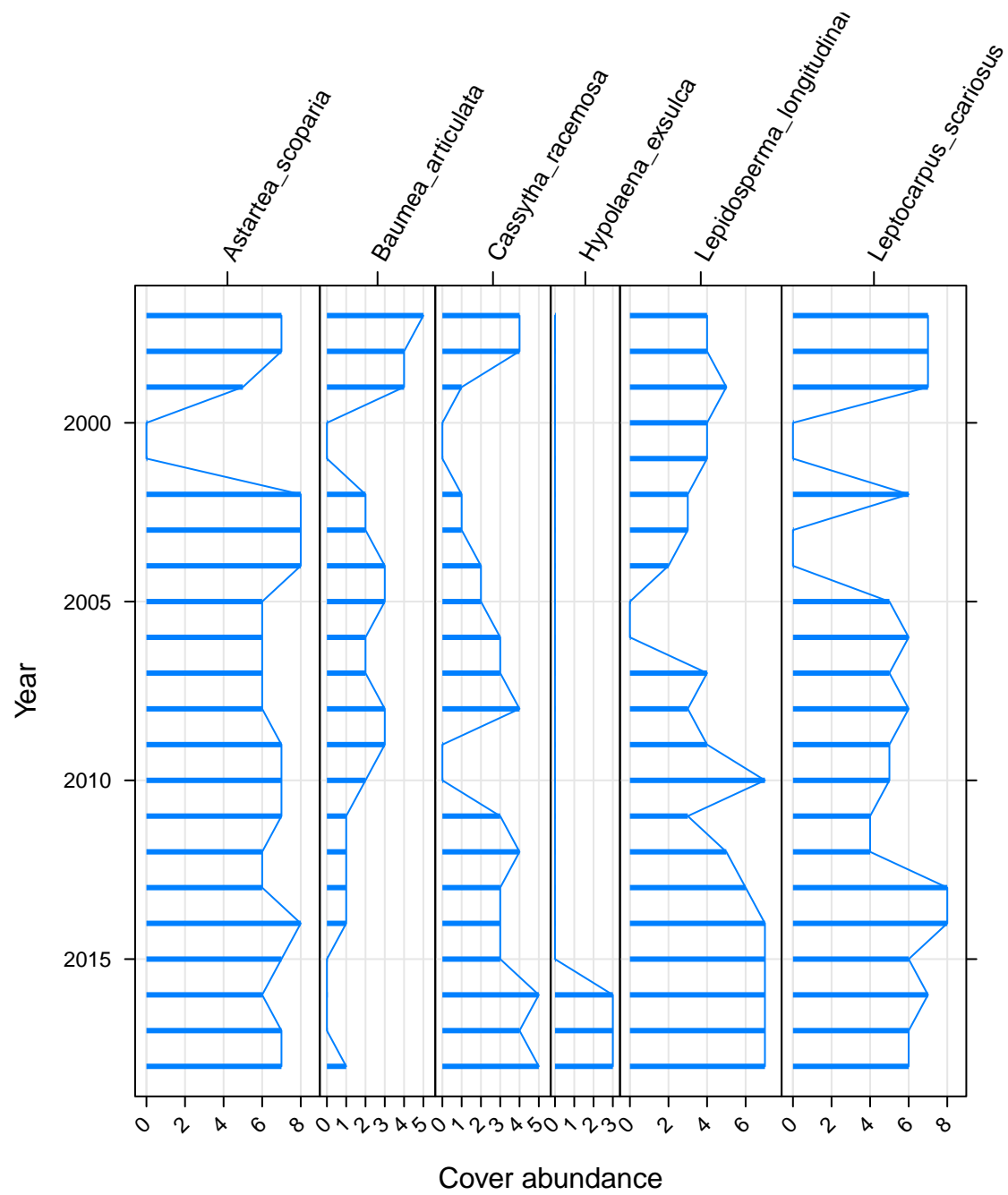
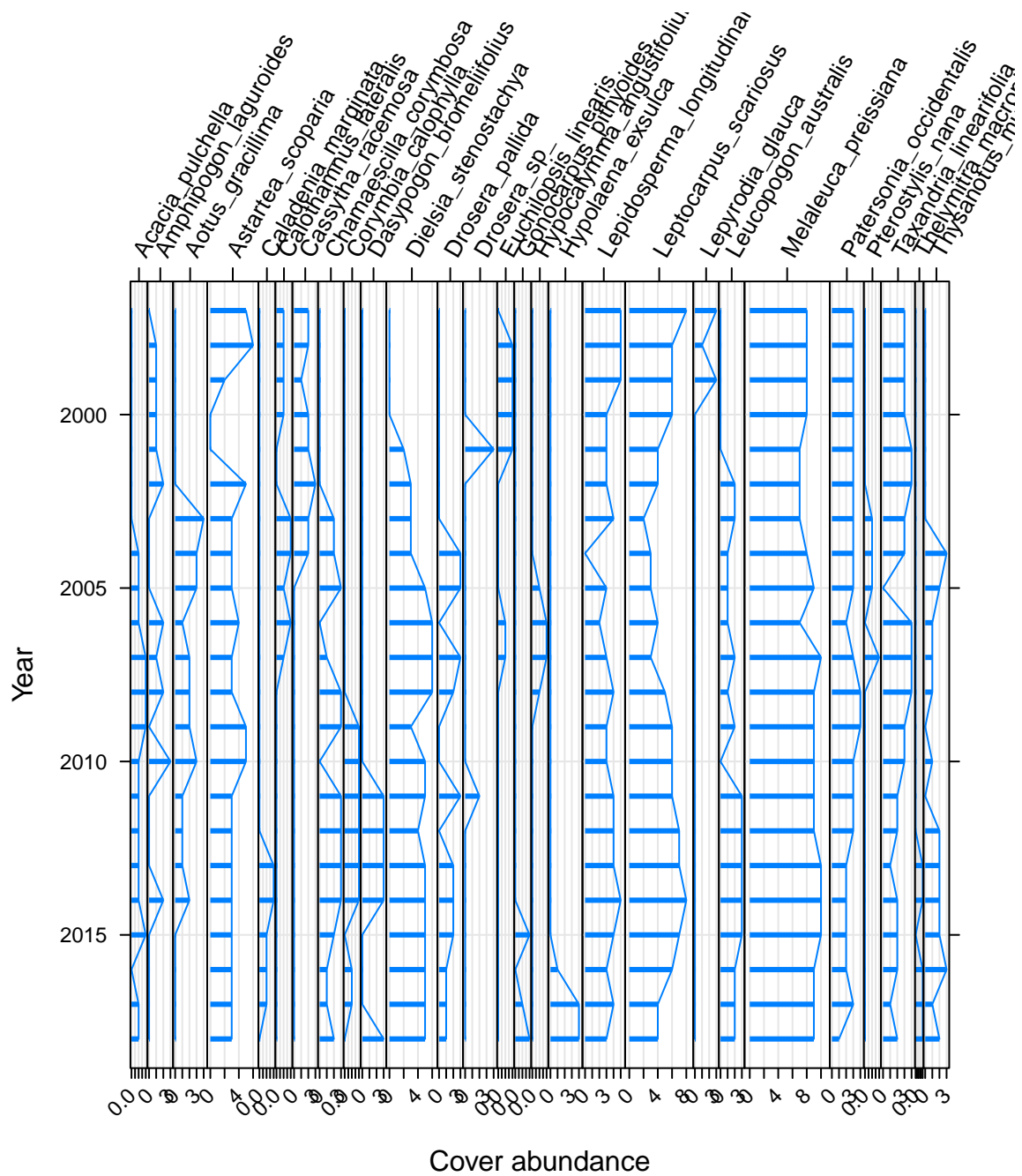
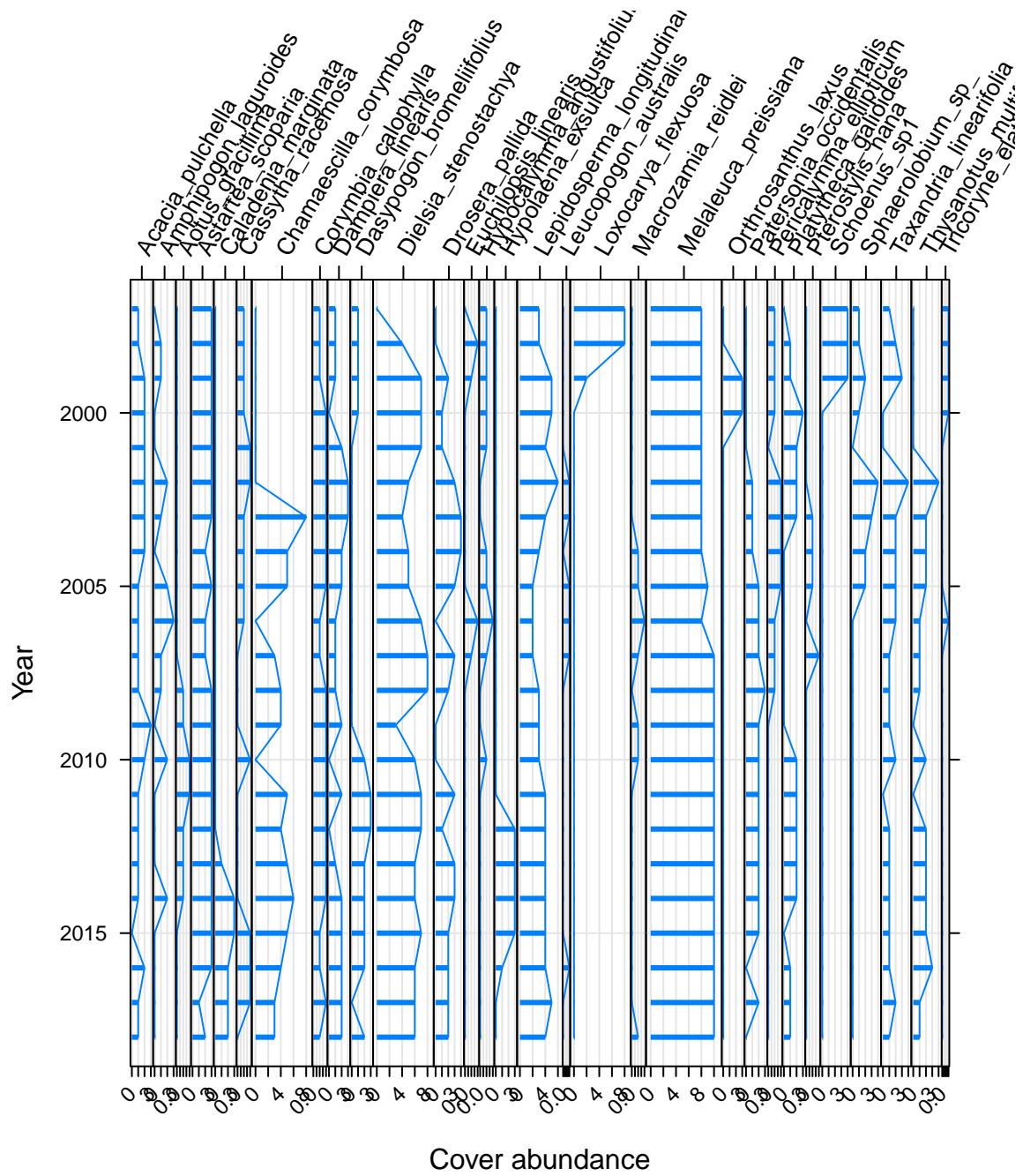
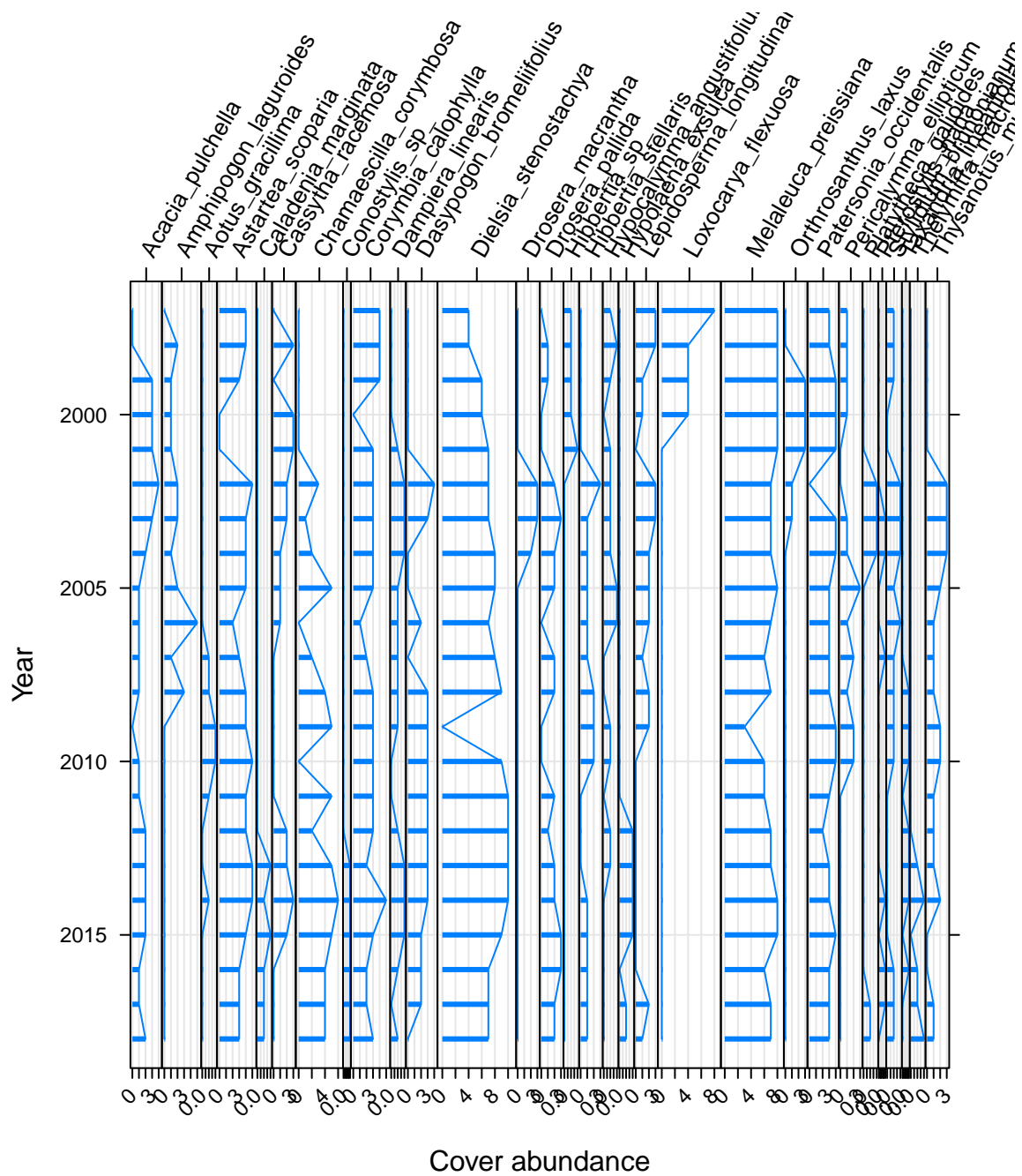


Figure 1: Ground and surface water levels recorded at bores and staff gauges in the vicinity of EMP 173









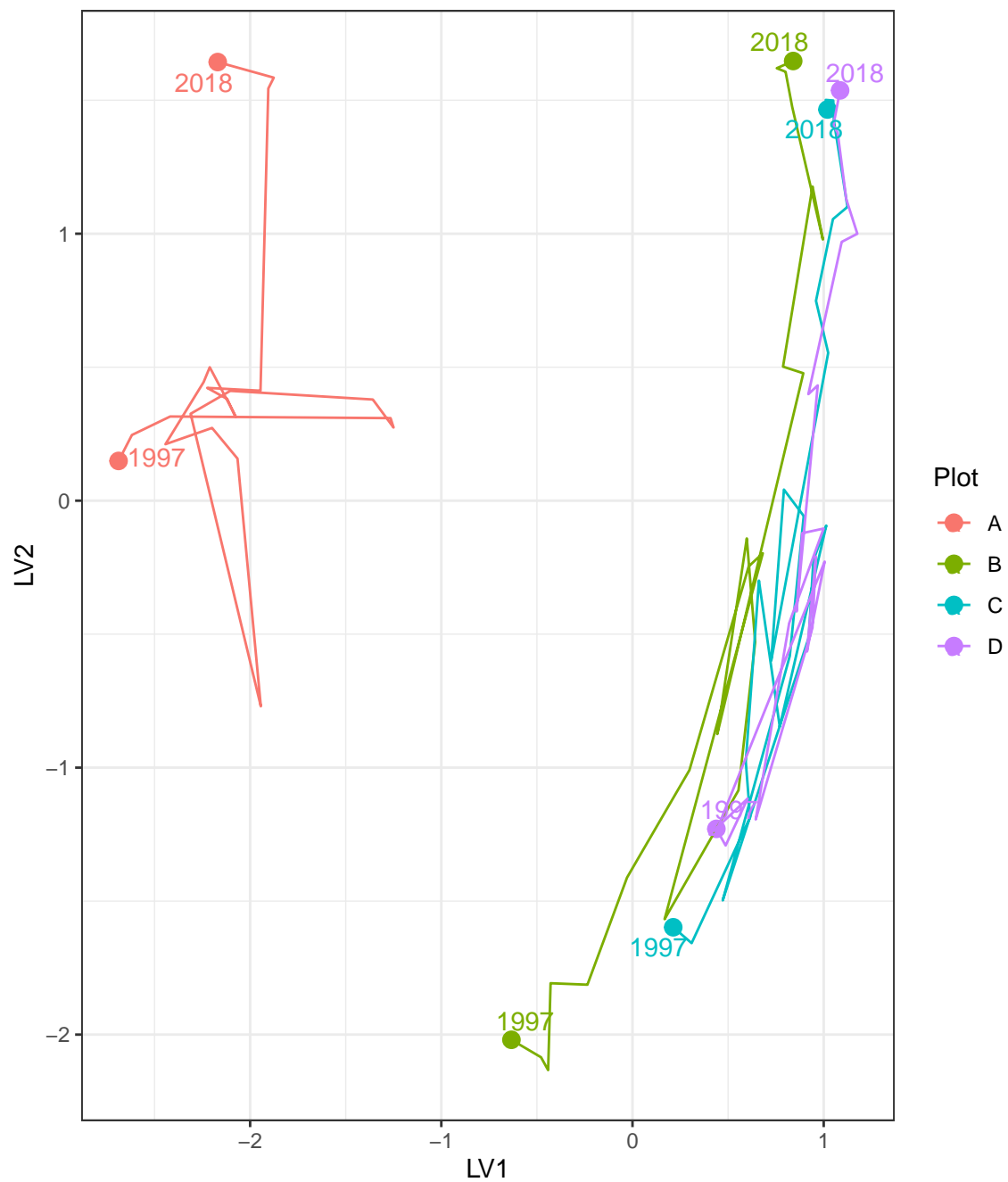


Figure 2: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

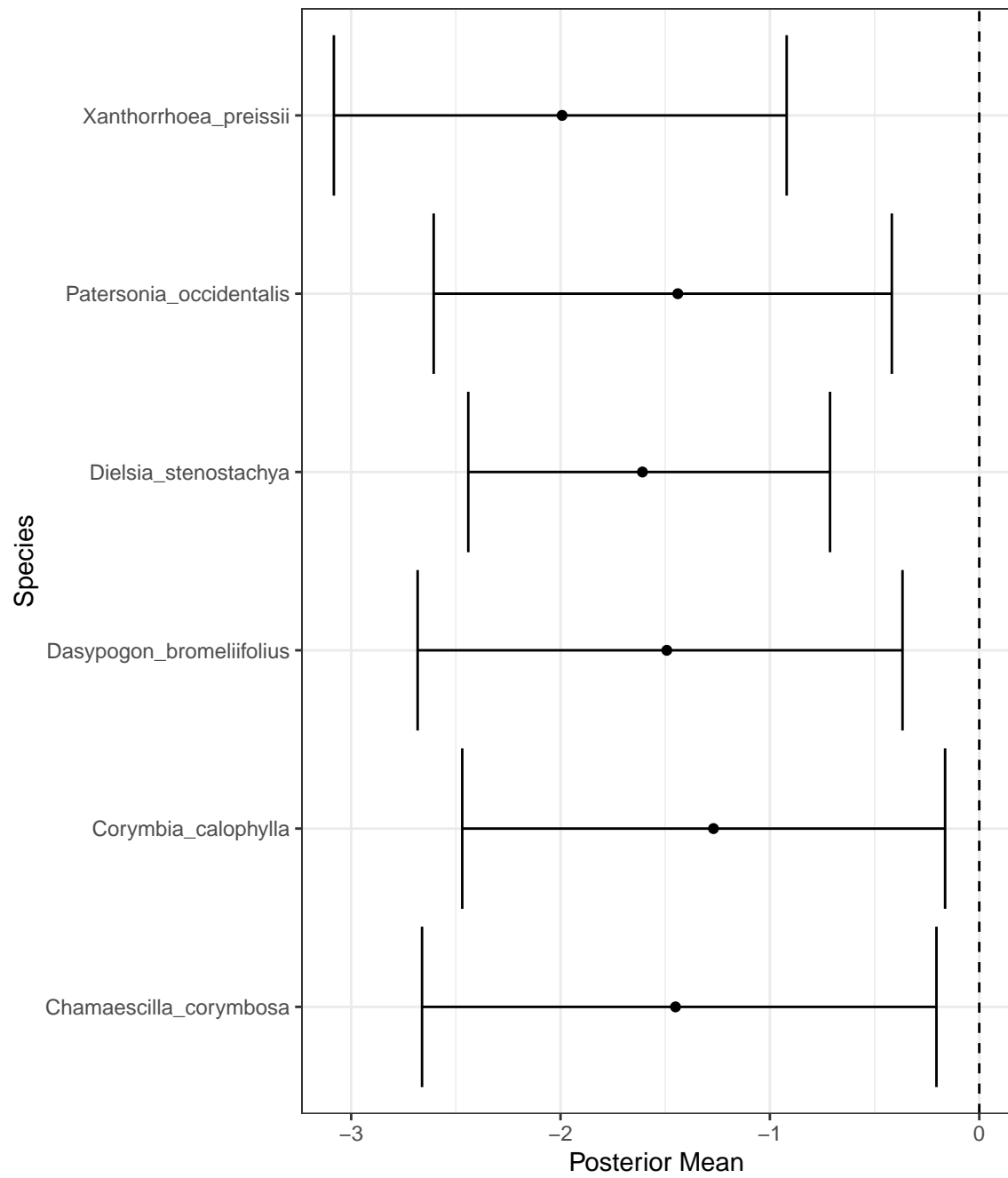
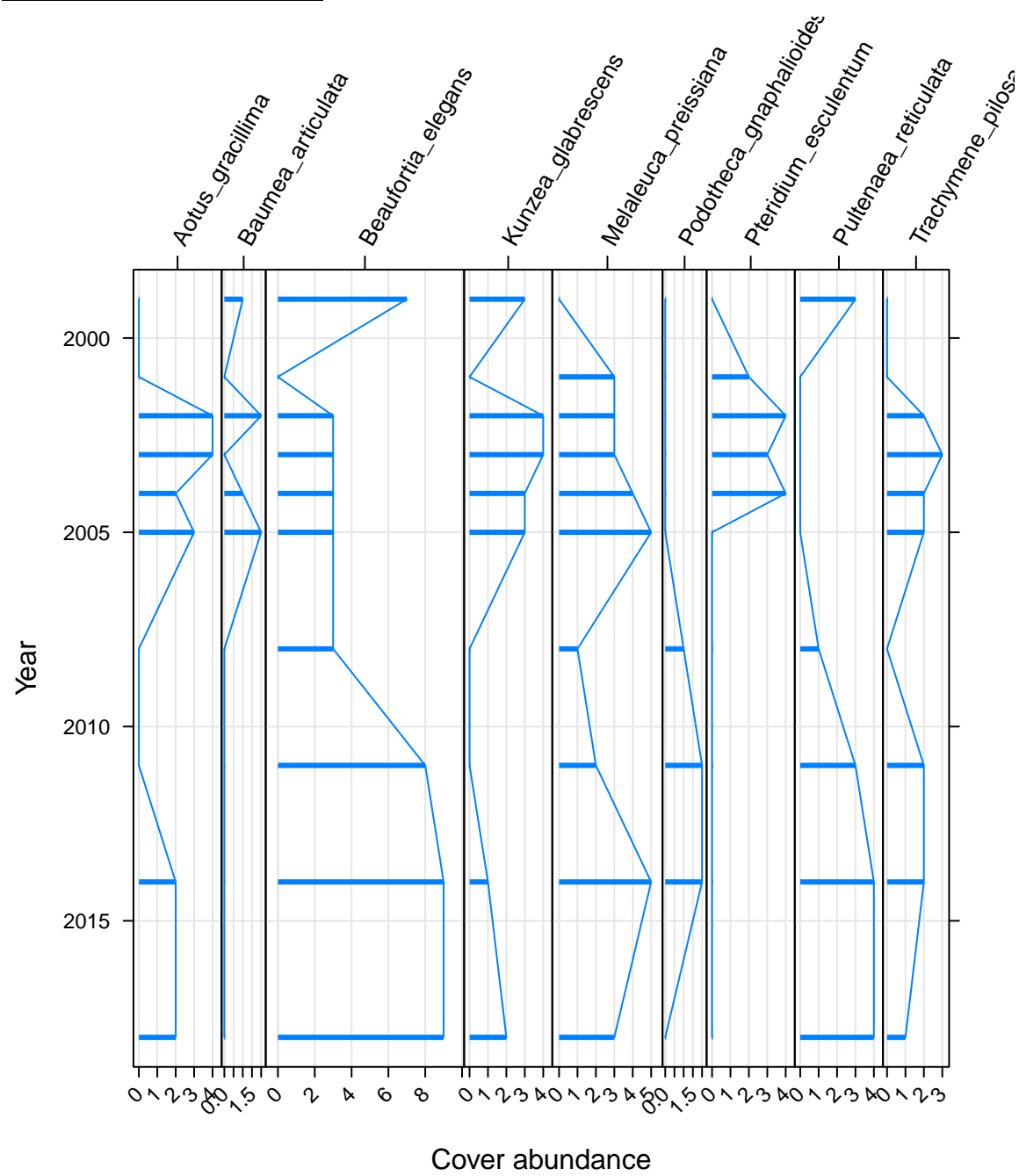


Figure 3: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

EMP 78

Five year summaries of surface water level data at EMP 78

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	66.191	66.021	0.170	July	June	-27.000
08/1999 - 07/2004	66.231	65.831	0.400	October	May	234.800
08/2004 - 07/2009	65.975	65.619	0.356	November	April	227.600
08/2009 - 07/2014	65.415	65.109	0.306	October	July	212.800
08/2014 - 07/2019	65.177	64.891	0.286	November	May	170.400



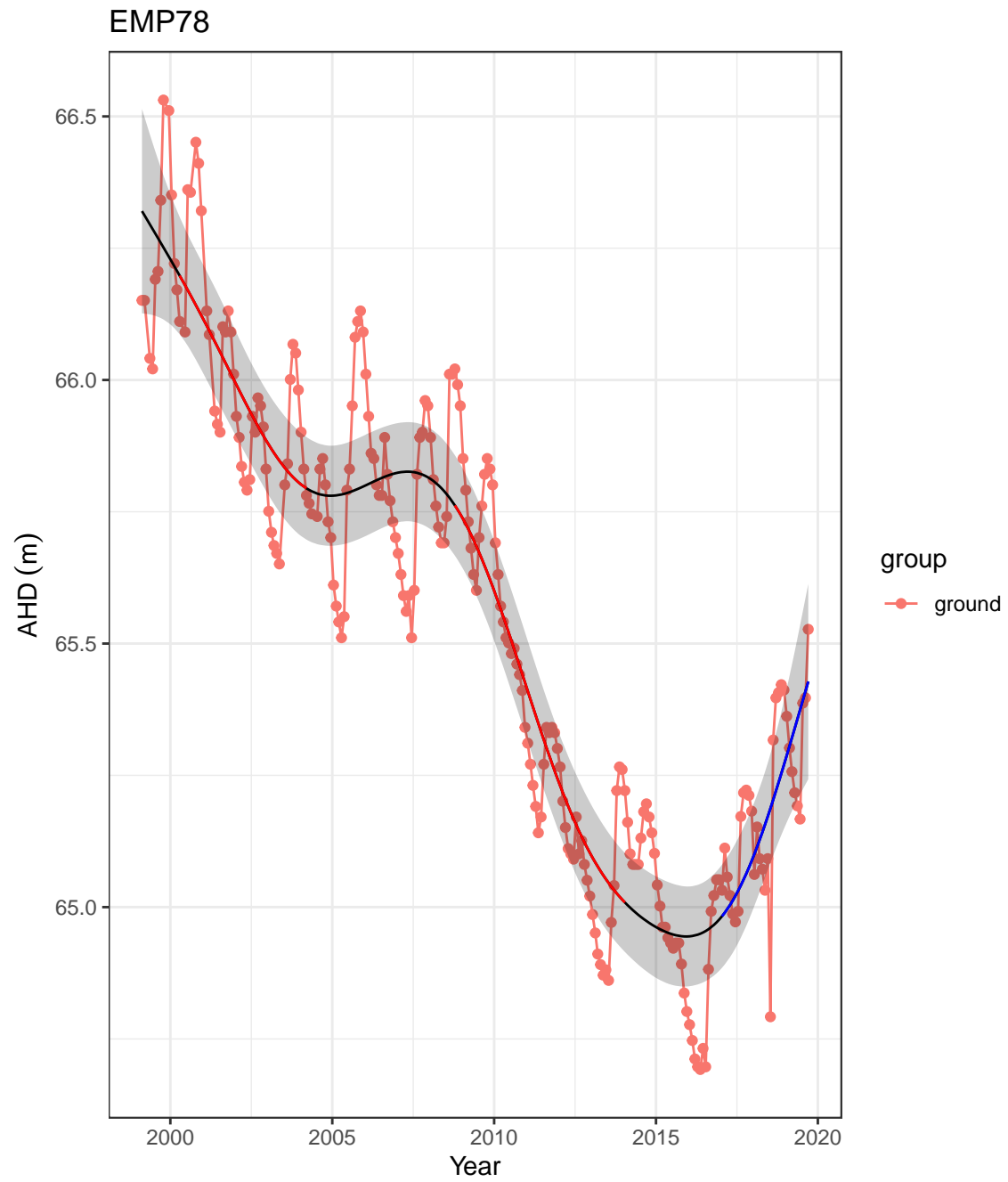
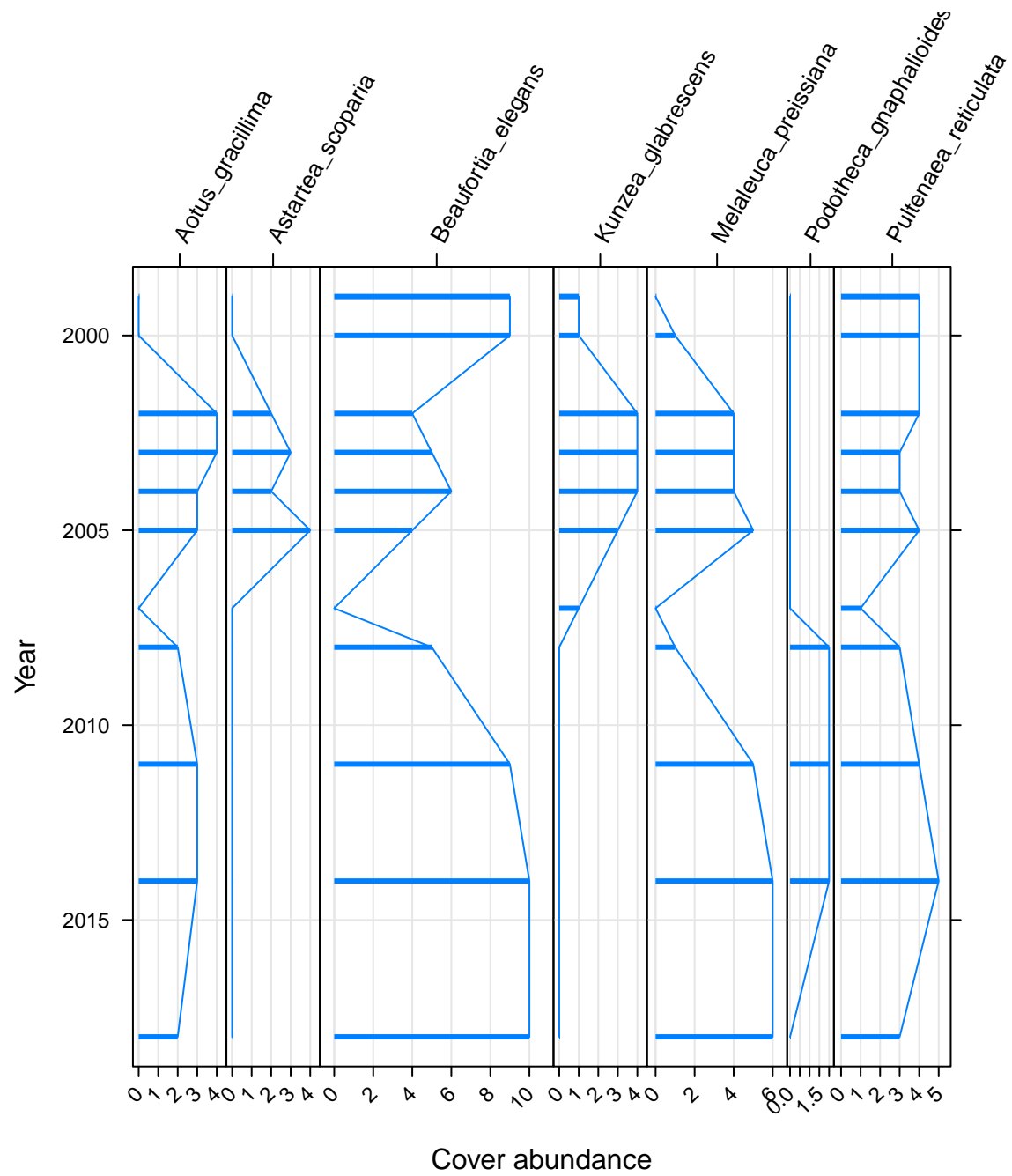
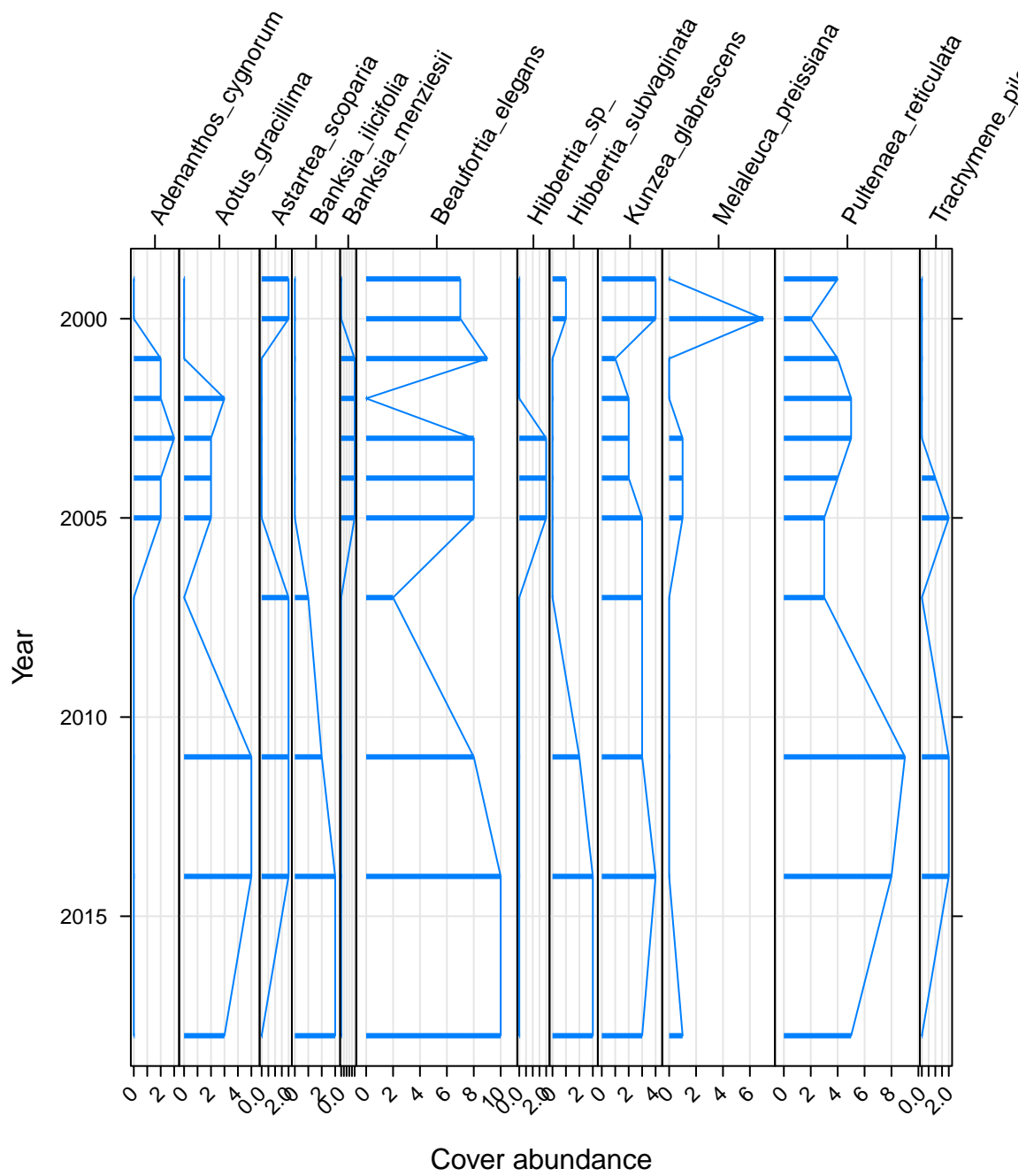
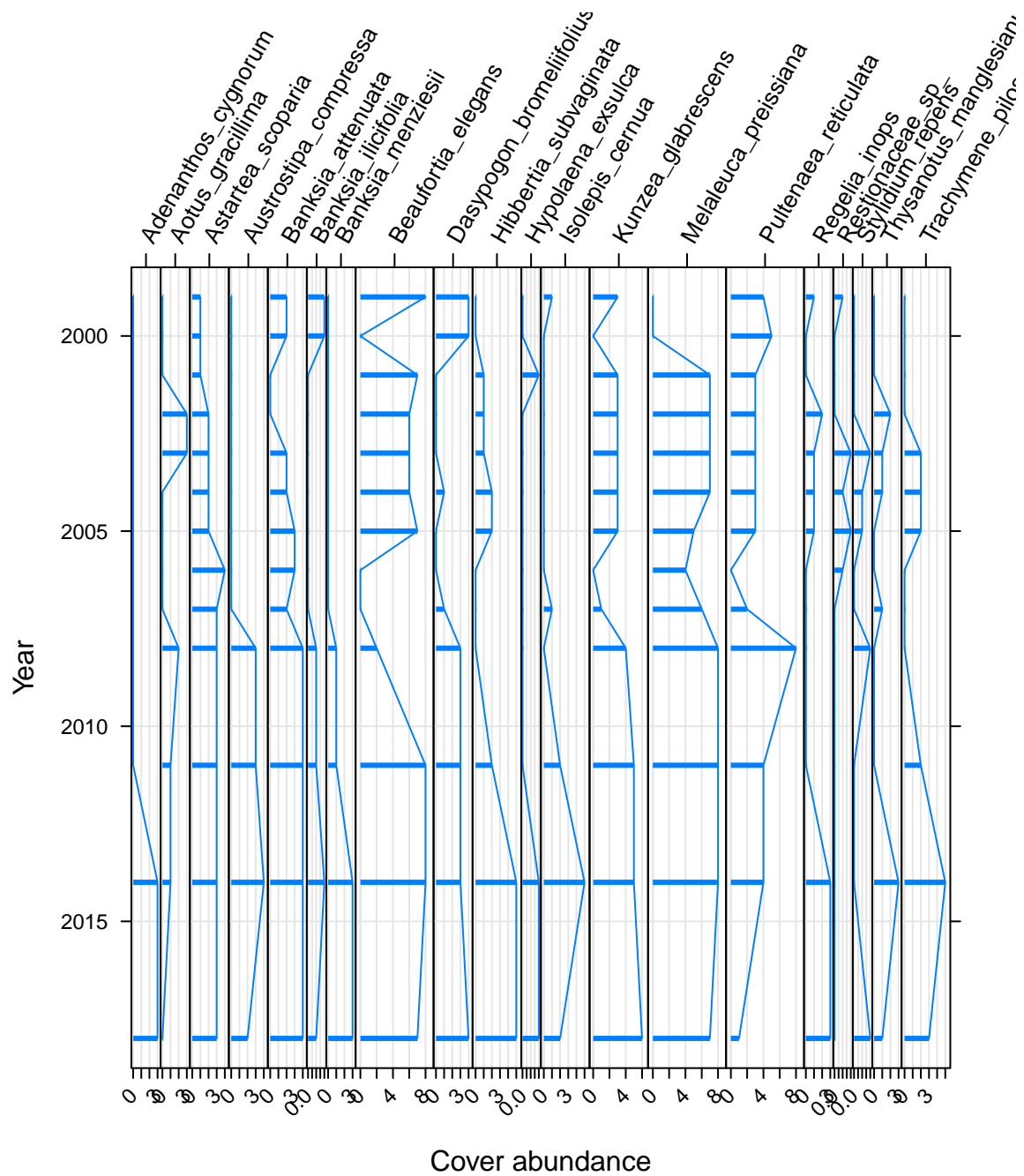


Figure 4: Ground and surface water levels recorded at bores and staff gauges in the vicinity of EMP 78







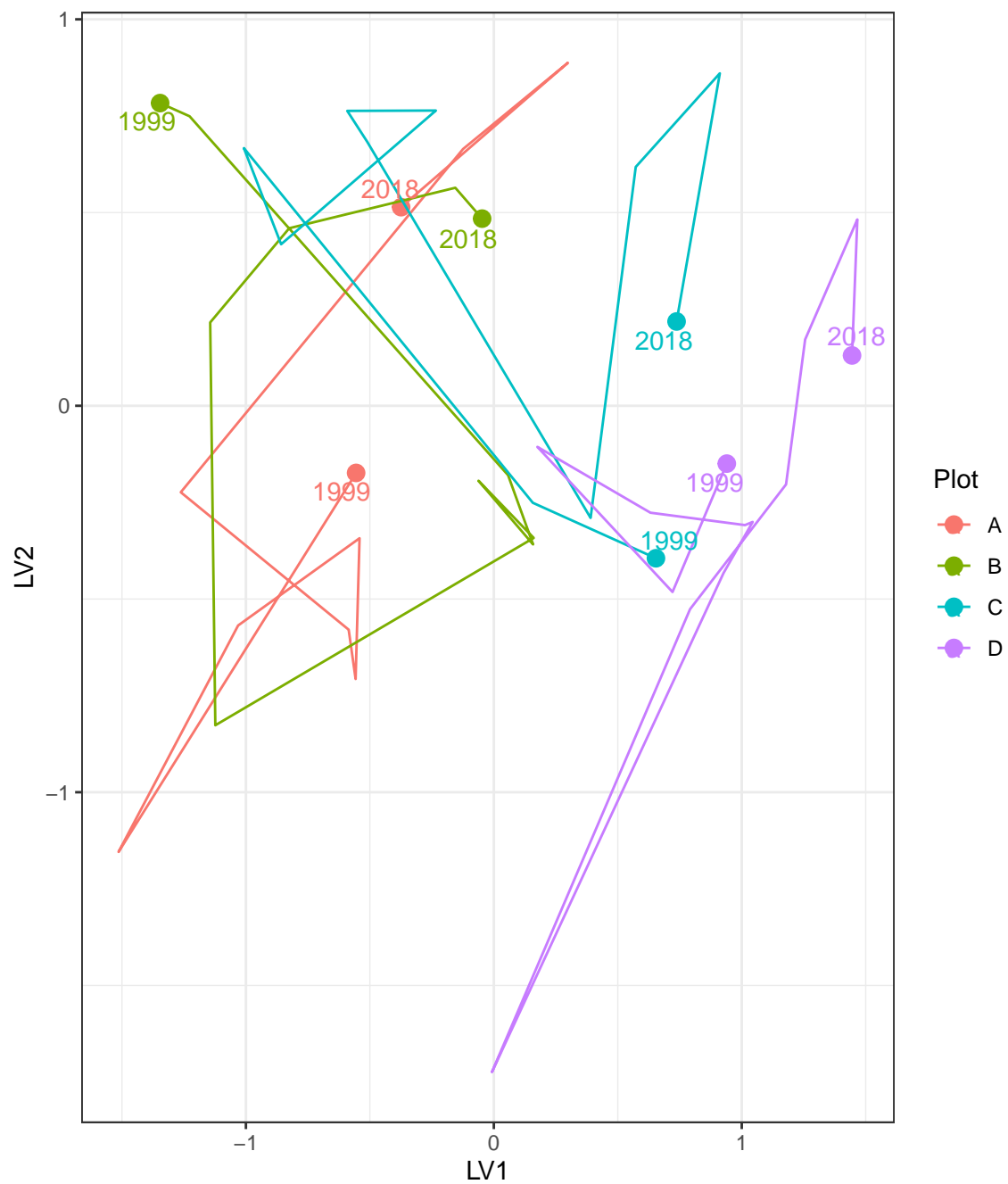


Figure 5: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

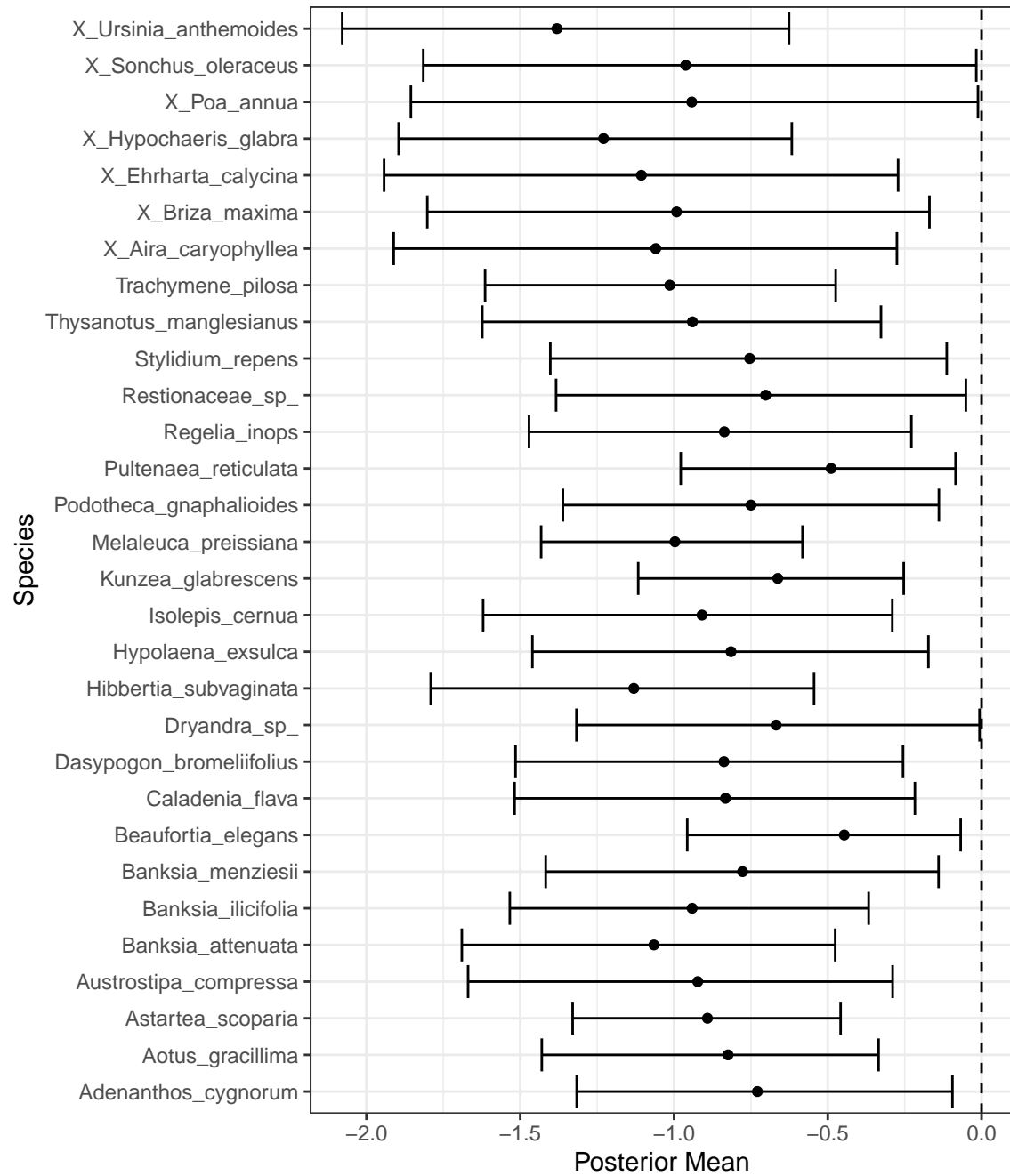


Figure 6: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

Gingin

Five year summaries of surface water level data at Gingin

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	39.628	39.174	0.454	October	July	218.800
08/1999 - 07/2004	39.162	38.644	0.518	December	May	198.200
08/2004 - 07/2009	38.534	38.106	0.428	October	June	212.600
08/2009 - 07/2014	37.930	37.530	0.400	October	May	221.400
08/2014 - 07/2019	37.783	37.352	0.431	November	May	141.000

Lake Goollelal

Lake Goollelal, located within the Yellagonga Regional Park, is recognised as an important waterbird habitat and drought refuge (FROEND 2006) as well as habitat for the Swan River Goby (*Pseudogobius olorum*) and the Western Pygmy Perch (*Edelia vittata*) (WAWA 1995). The permanent deep waters found in the lake not only provides significant habitat for fauna and fringing vegetation, but also has significant value as a place of public enjoyment.

Surface water levels recorded at Lake Goollelal reveal peak levels generally occur between September and November and lowest water levels between March and May. There has been a consistent range of about 0.7 m in annual water level during this period. There has been a general trend of decreasing water levels since 1995 although recent increases since 2016 show surface waters at a similar depth to 1990 levels. Surface water levels show similar trends to groundwater levels at a nearby bore () as the lake is largely fed by groundwaters. Although the preferred minimum threshold of 26.2 mAHD has not been breached, it is likely the threshold is set too low as the acidification of waters entering the lake is a concern (Quintero Vasquez 2018).

Five year summaries of surface water level data at Goollelal

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	27.534	26.754	0.780	October	May	206.800
08/1999 - 07/2004	27.485	26.684	0.800	September	March	206.400
08/2004 - 07/2009	27.379	26.628	0.751	September	April	137.400
08/2009 - 07/2014	27.244	26.513	0.731	October	April	189.600
08/2014 - 07/2019	27.386	26.708	0.678	November	April	138.600

The composition of vegetation at Lake Goollelal has been assessed 14 times between 1997 and 2014 at four plots [I NEED TO READ THE 2014 VEG REPORT]. Plot A represents fringing *Melaleuca raphiophylla*/*Eucalyptus rudis* complex and a stable community of the native sedges, *Baumea articulata* and *Lepidosperma gladiatum*. The *Melaleuca raphiophylla*/*Eucalyptus rudis* complex continues throughout the transect, which has also remained relatively stable in terms of cover abundance since 2002.

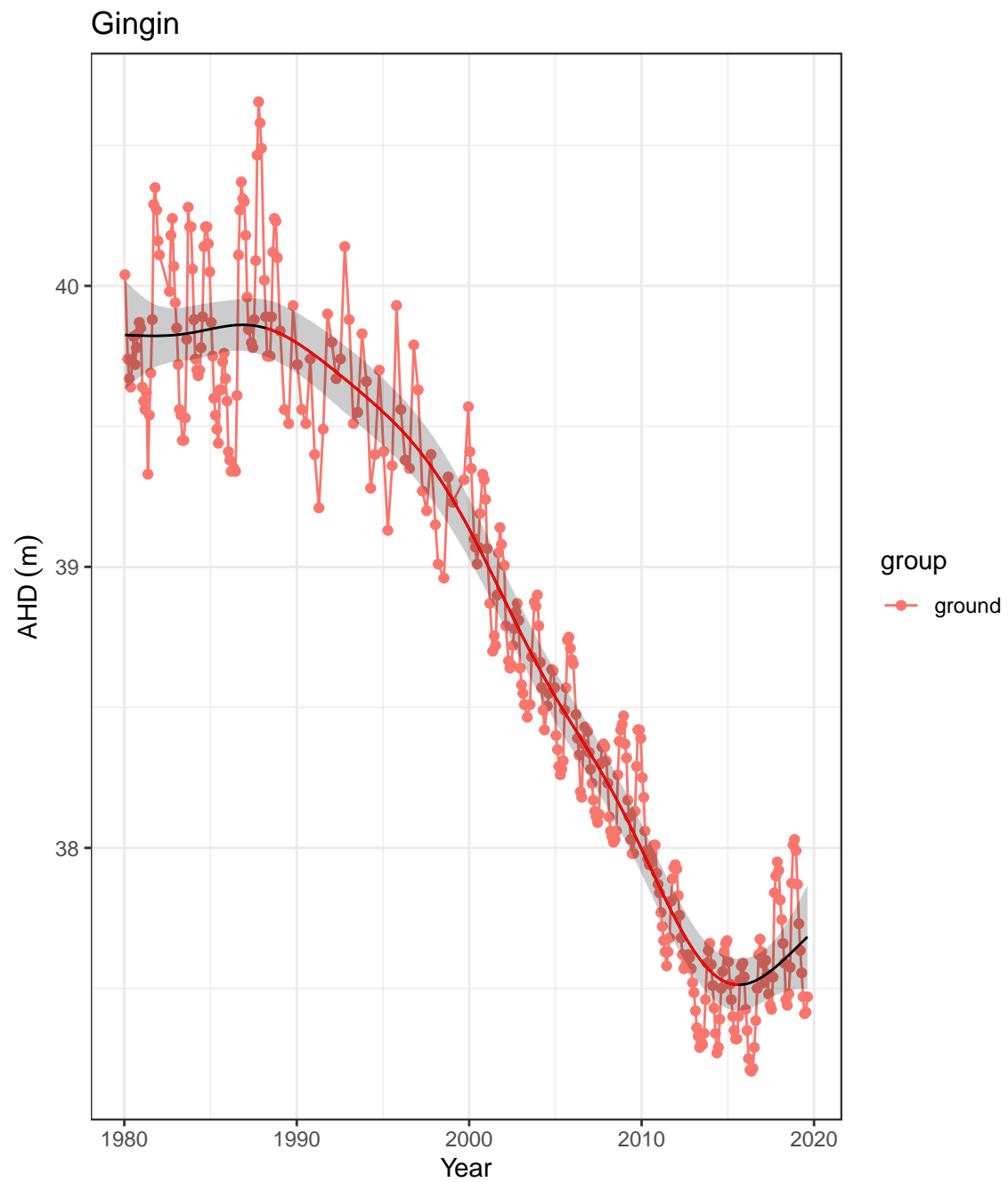


Figure 7: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Gingin

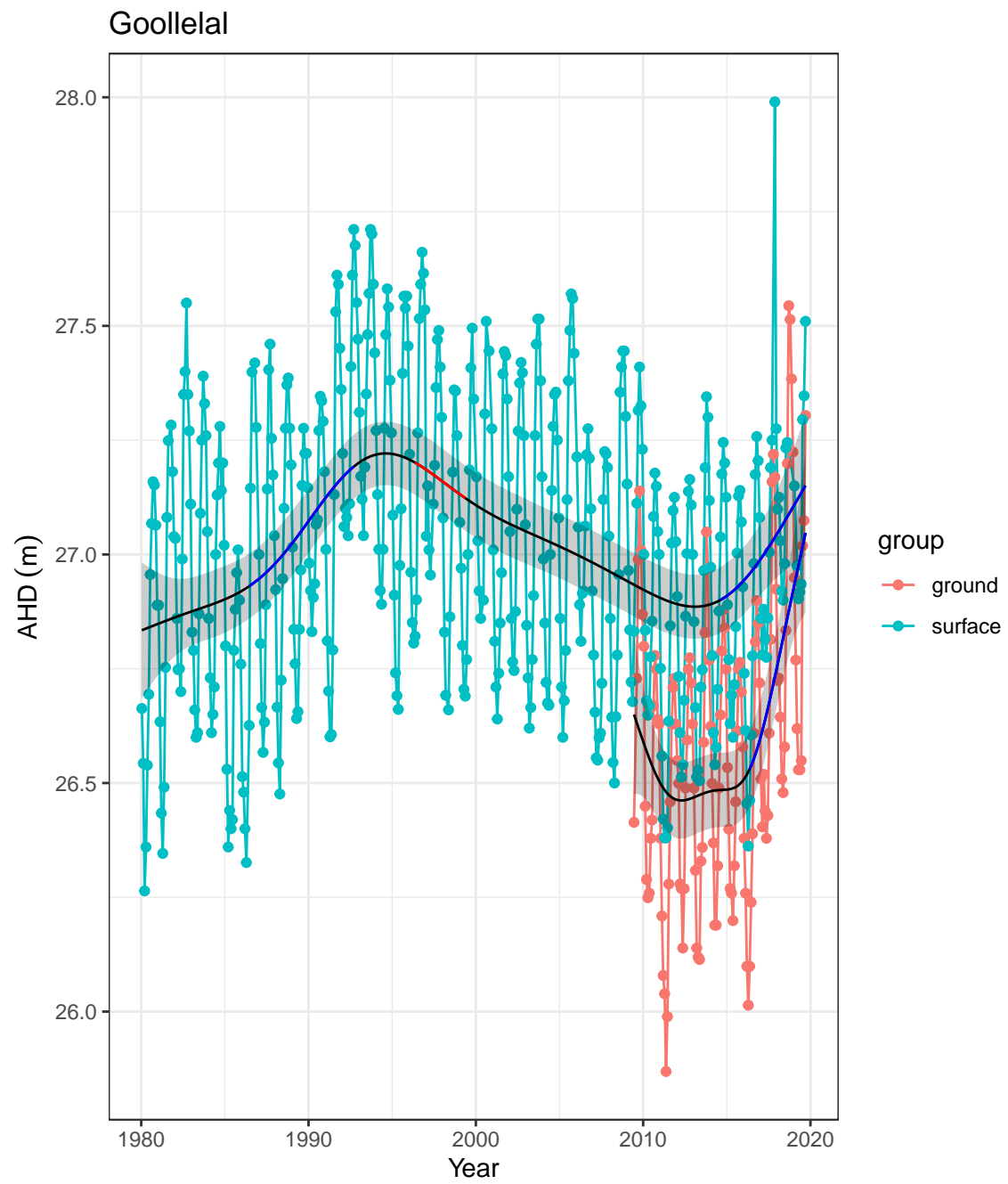
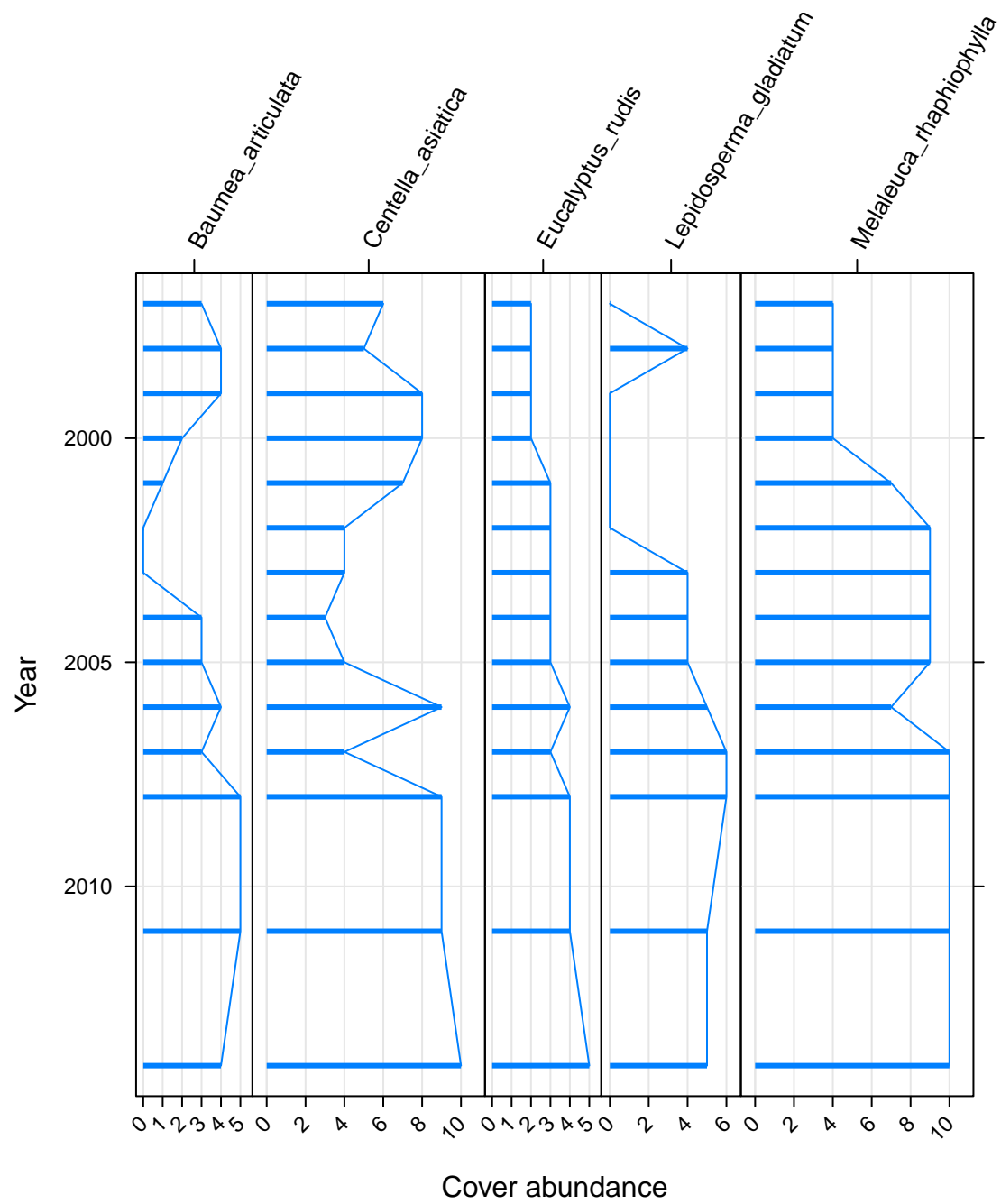
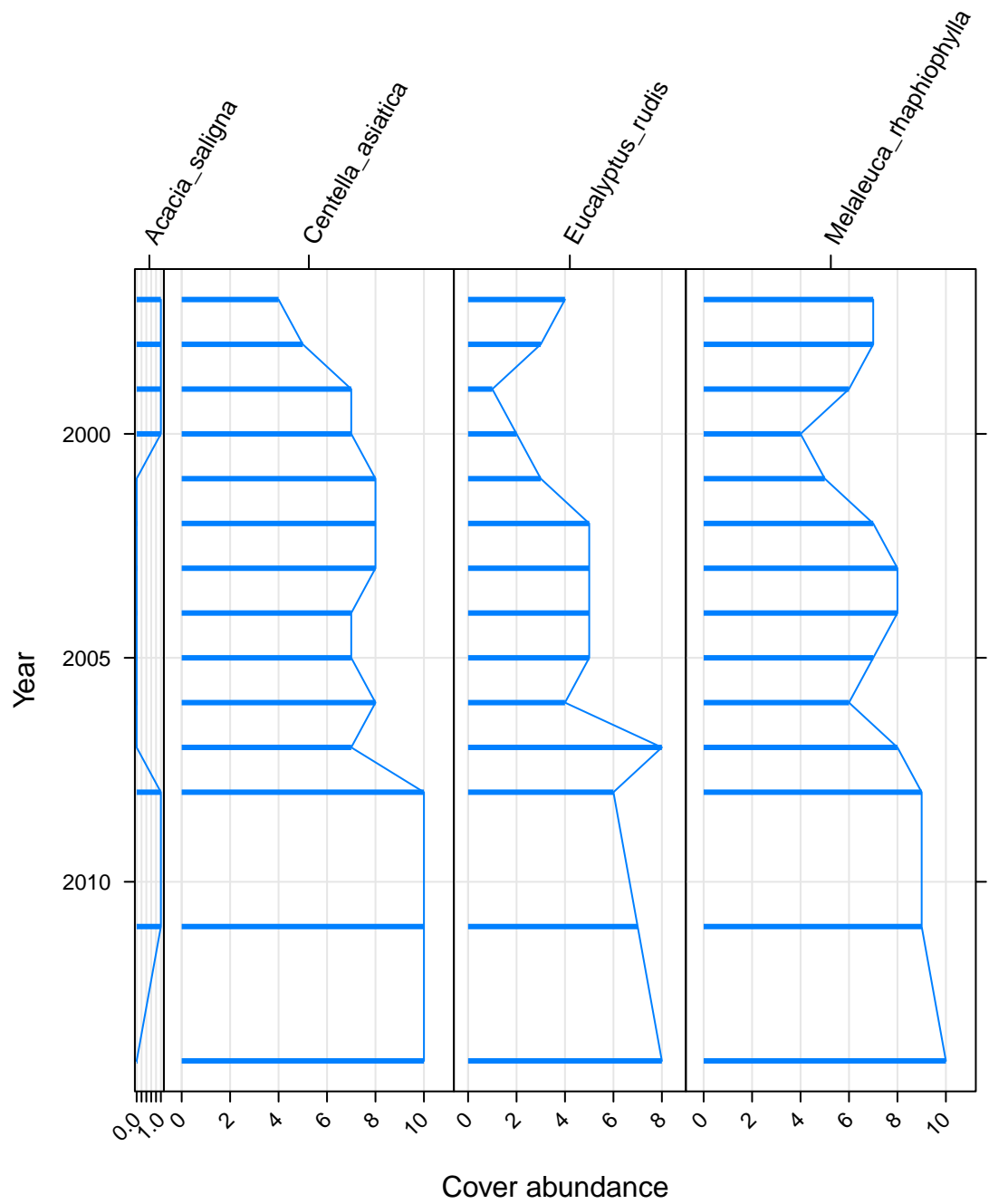
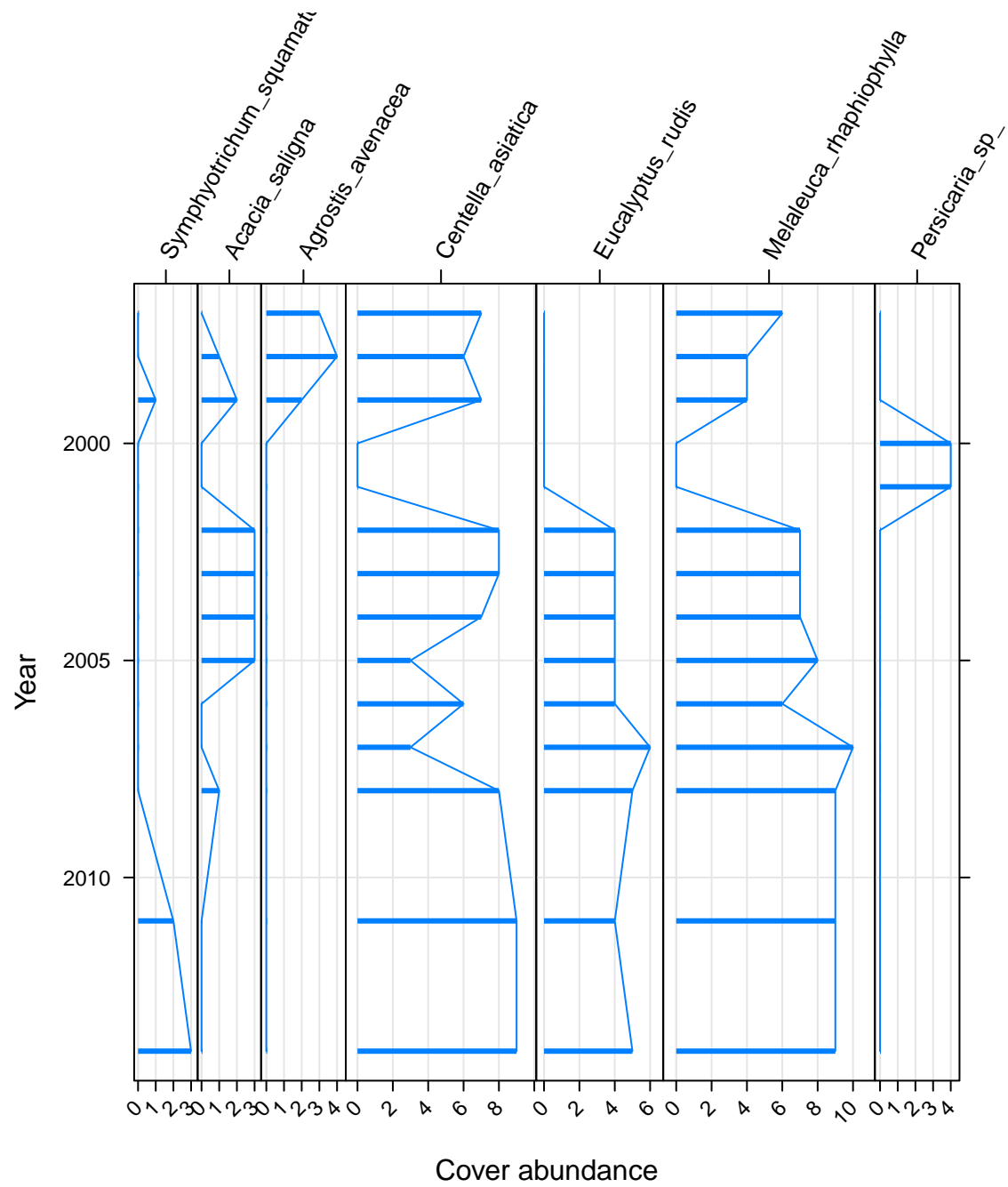
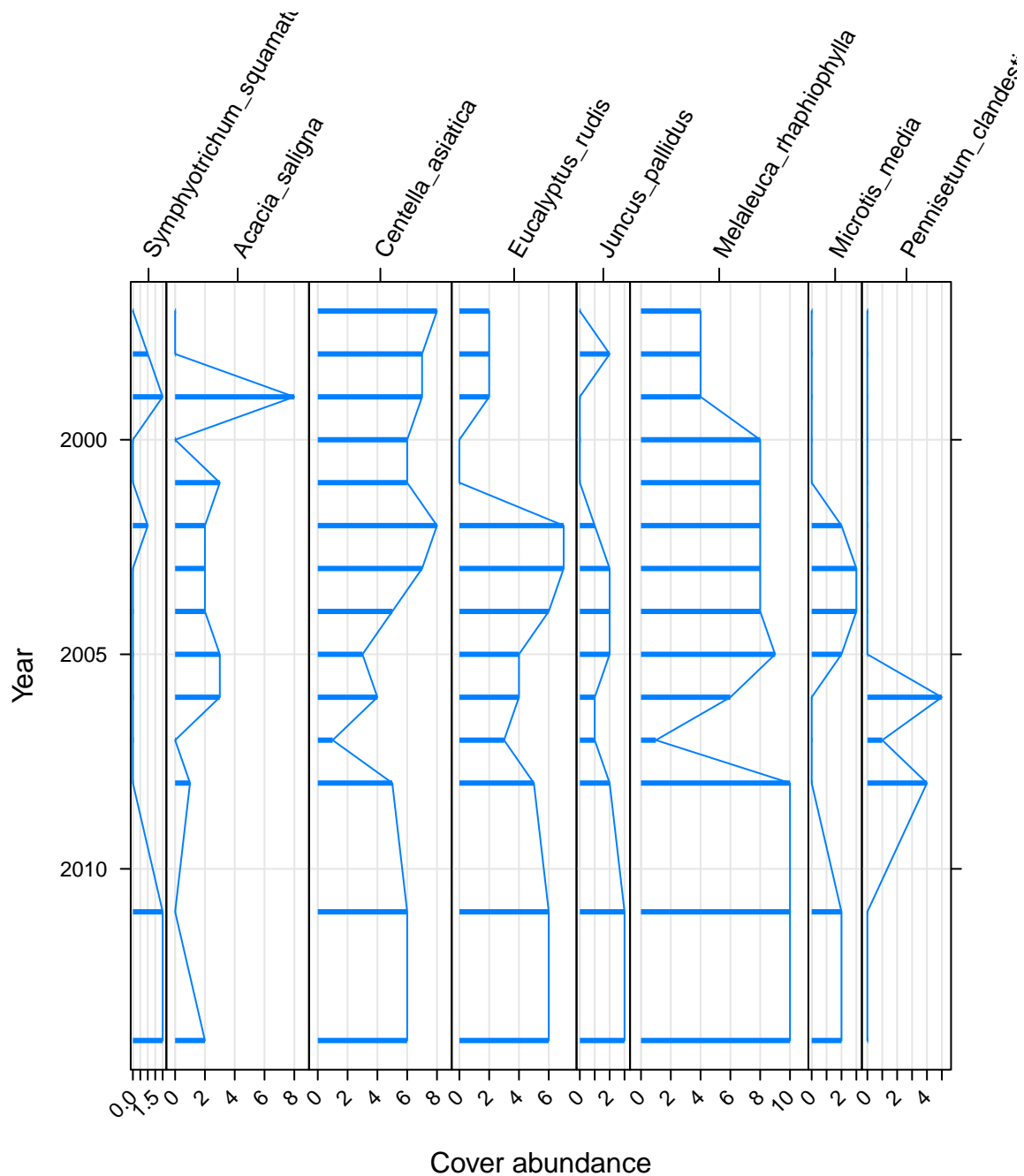


Figure 8: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Goollelal









Ordination reveals that Plot A has a distinct assemblage to the other plots but has displayed similar vegetation compositional changes. Shifts in compositional change has followed similar trajectories for each of the plots. All plots show an initial shift in community cover abundance from the 1997 survey and a return to 1997-like composition in the recent survey years.

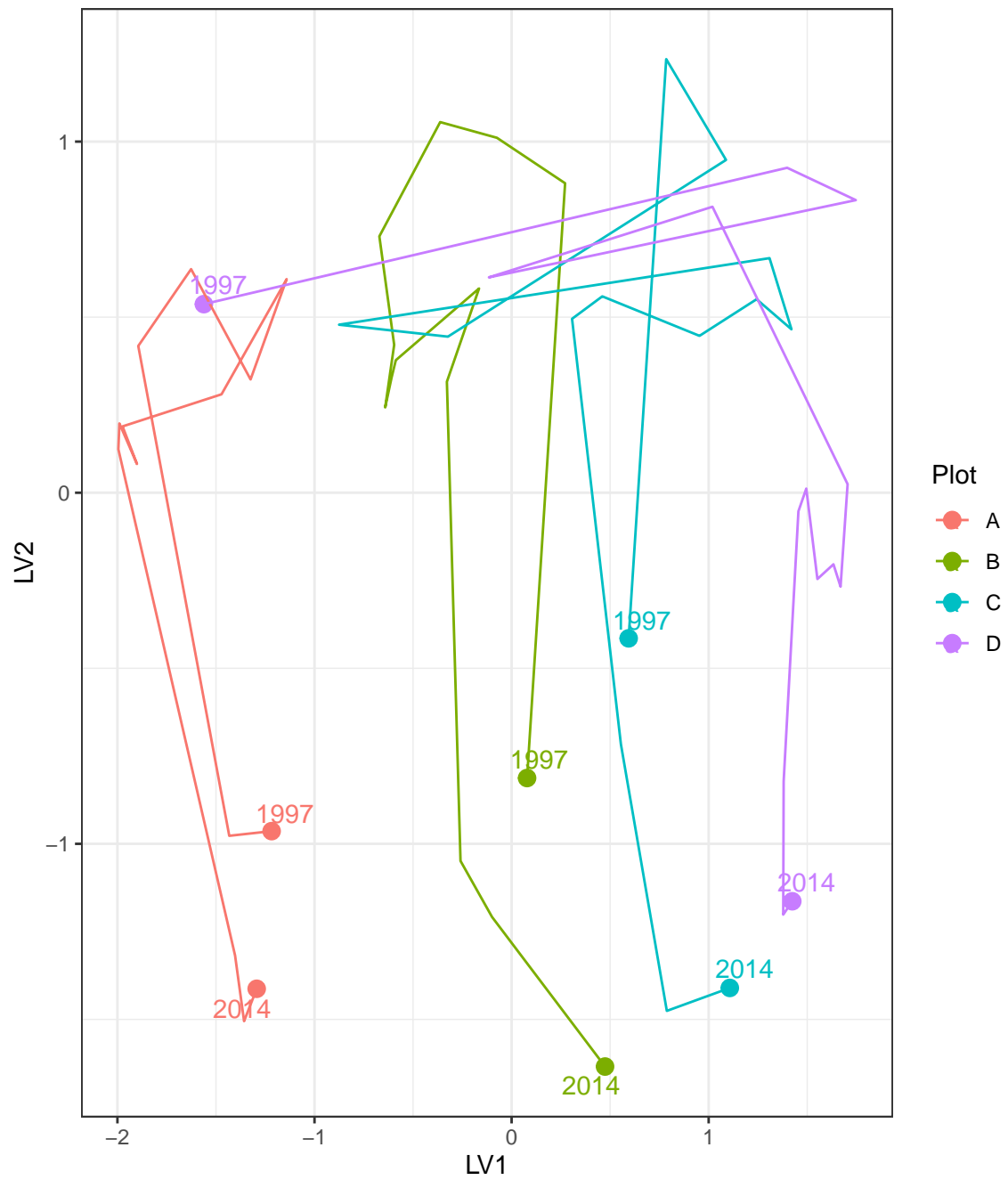


Figure 9: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

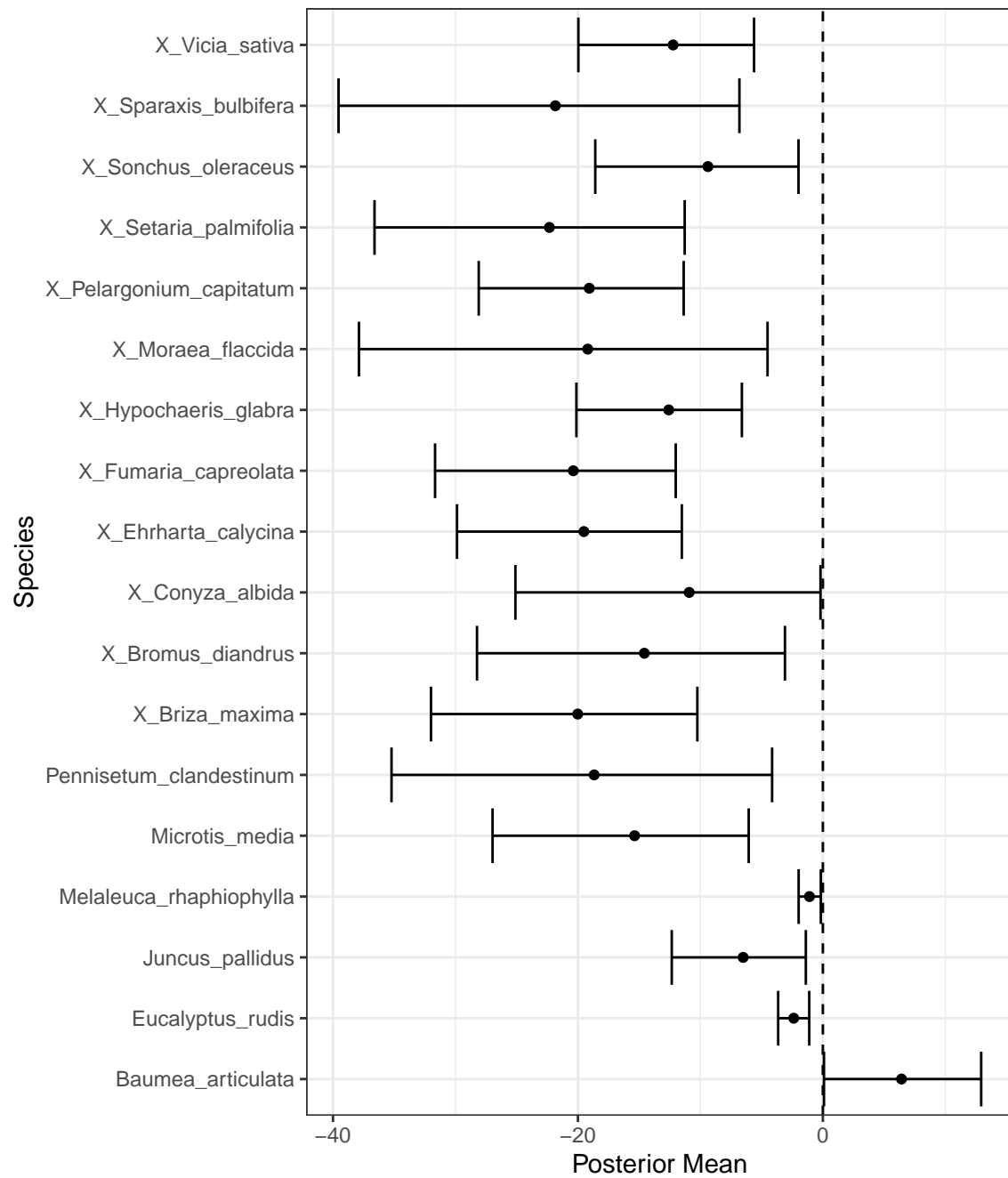
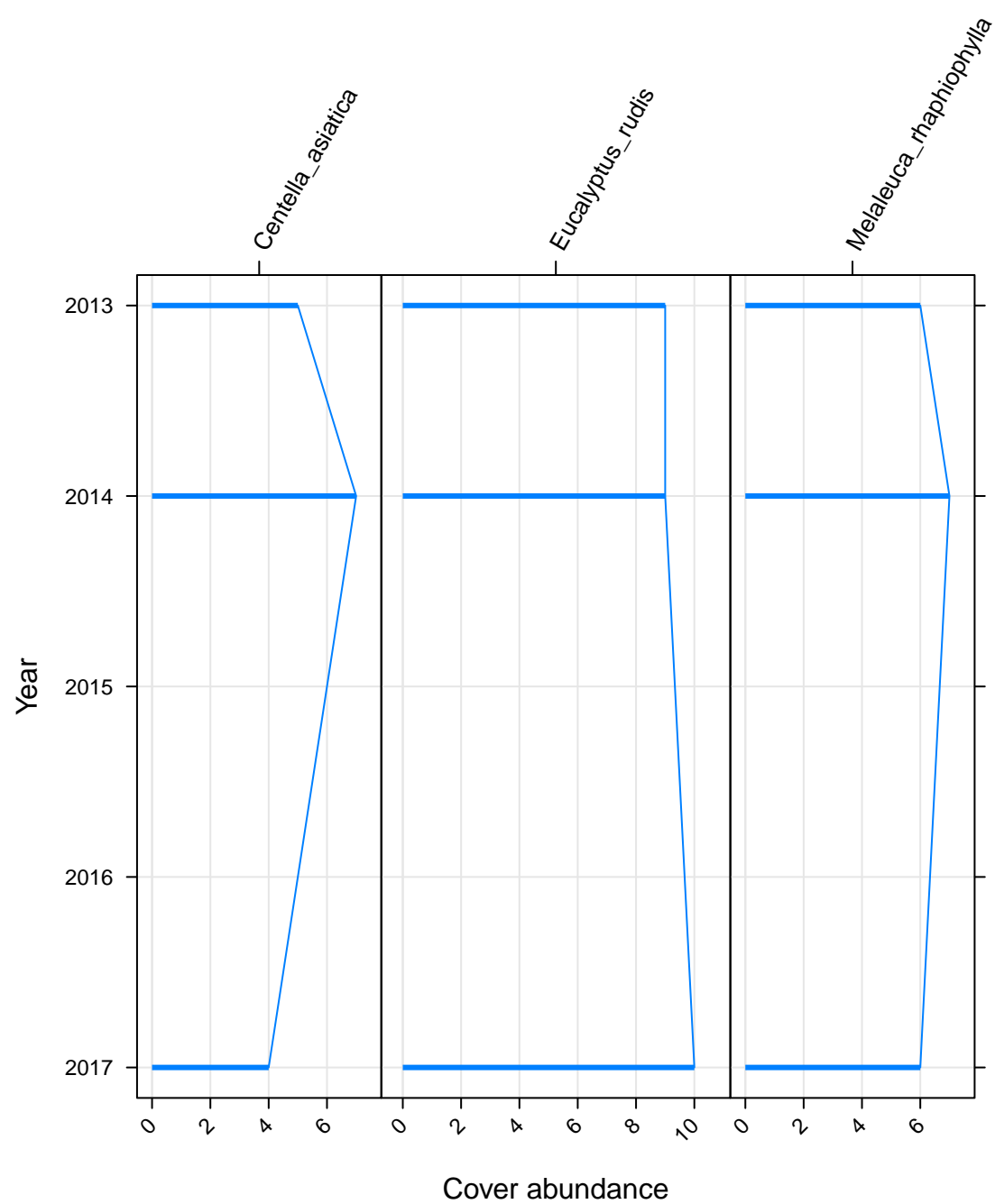


Figure 10: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

Gwelup

Five year summaries of surface water level data at Gwelup

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	7.515	5.661	1.854	September	April	238.800
08/1999 - 07/2004	6.664	5.146	1.518	October	April	171.600
08/2004 - 07/2009	6.322	5.000	1.322	September	December	14.000
08/2009 - 07/2014	6.146	4.972	1.174	October	January	138.400
08/2014 - 07/2019	7.251	5.592	1.659	October	April	221.800



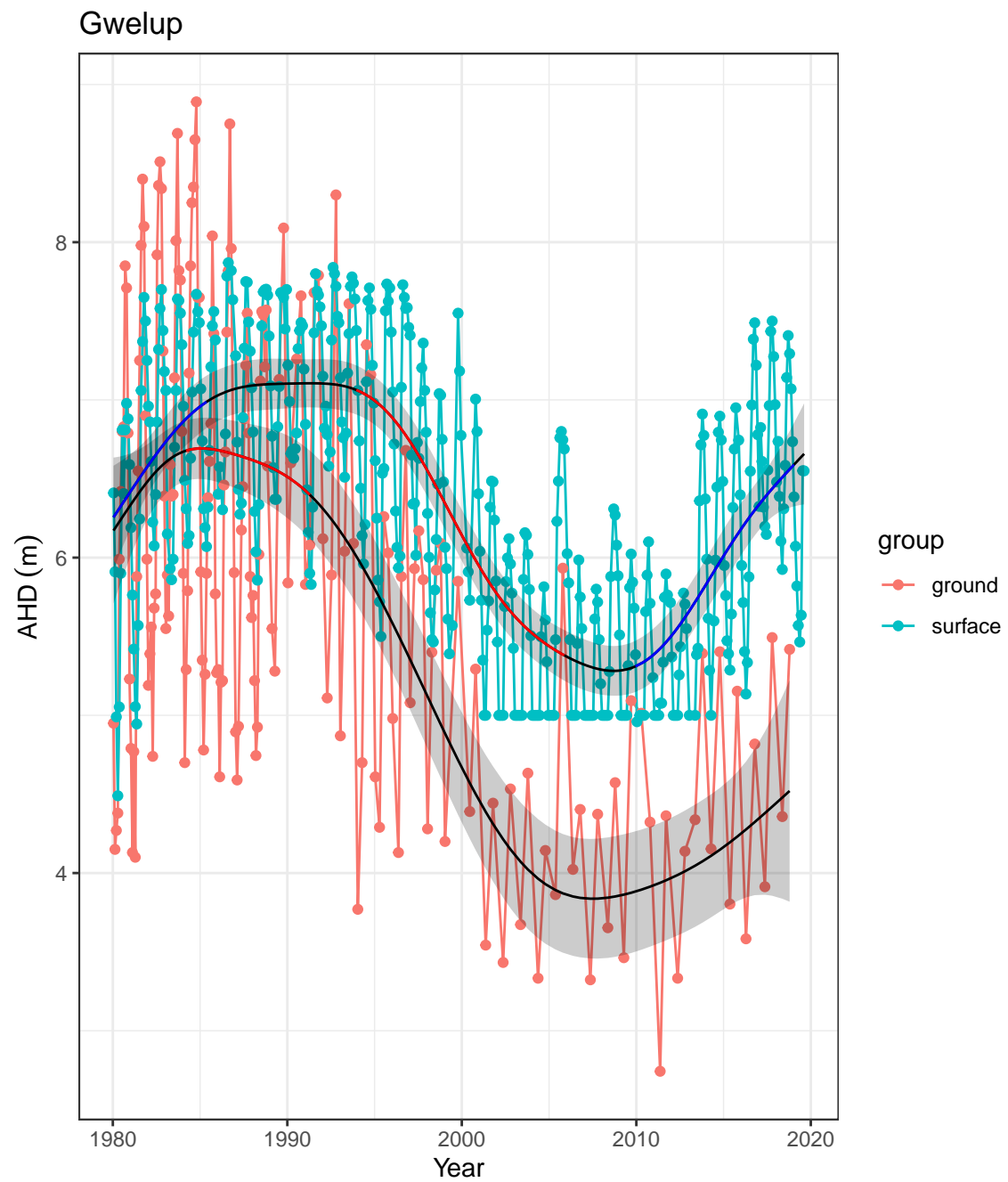
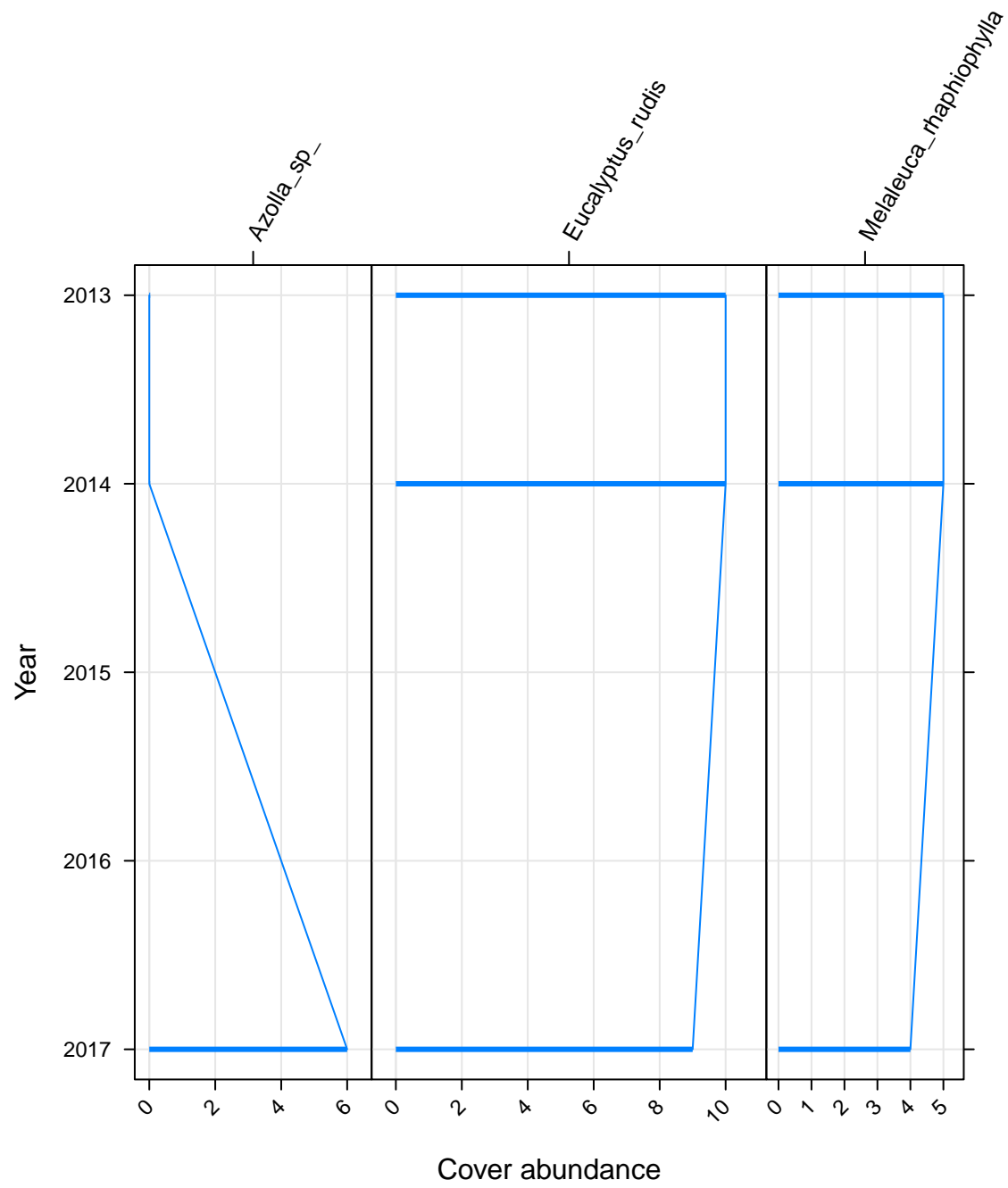
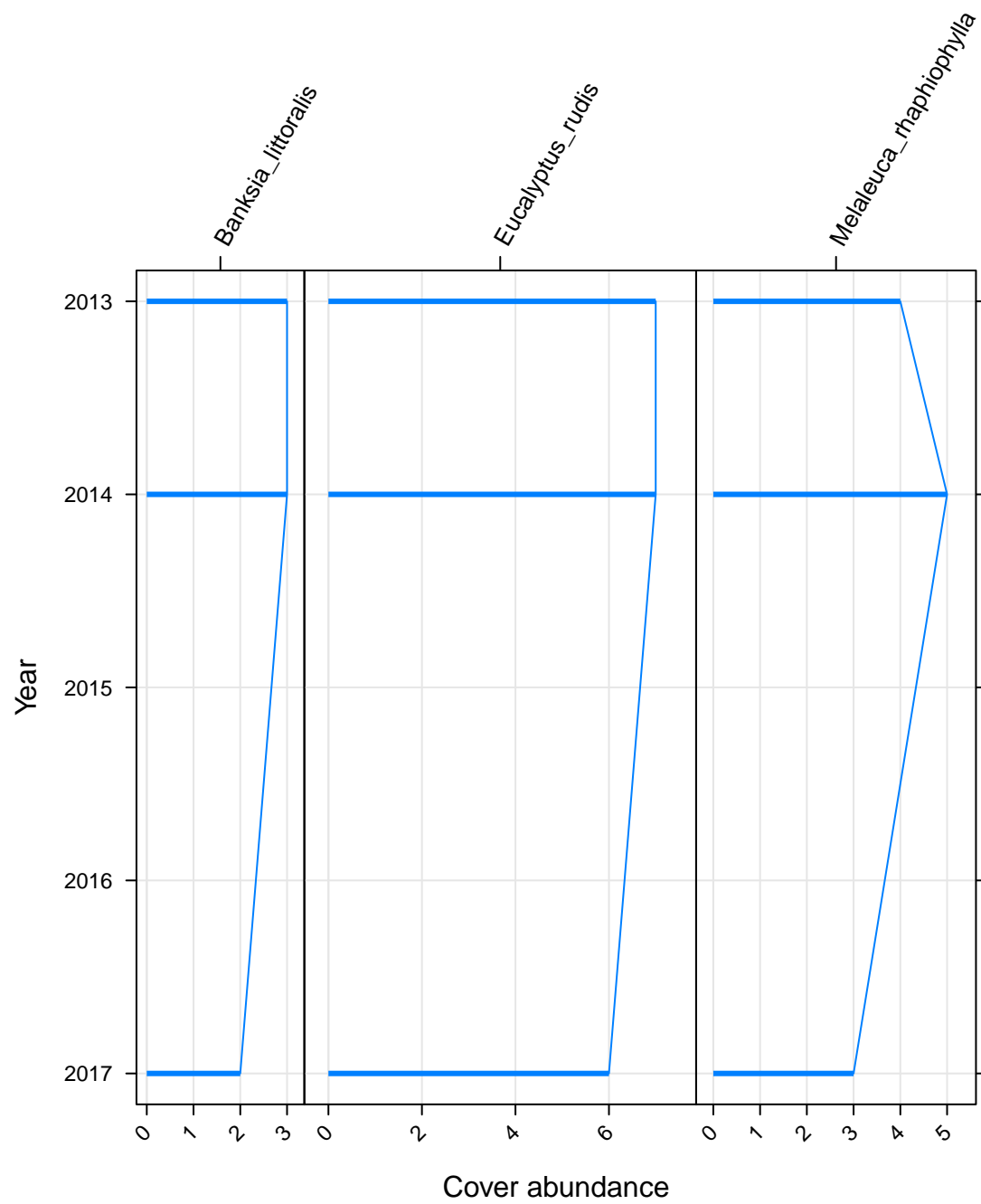


Figure 11: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Gwelup





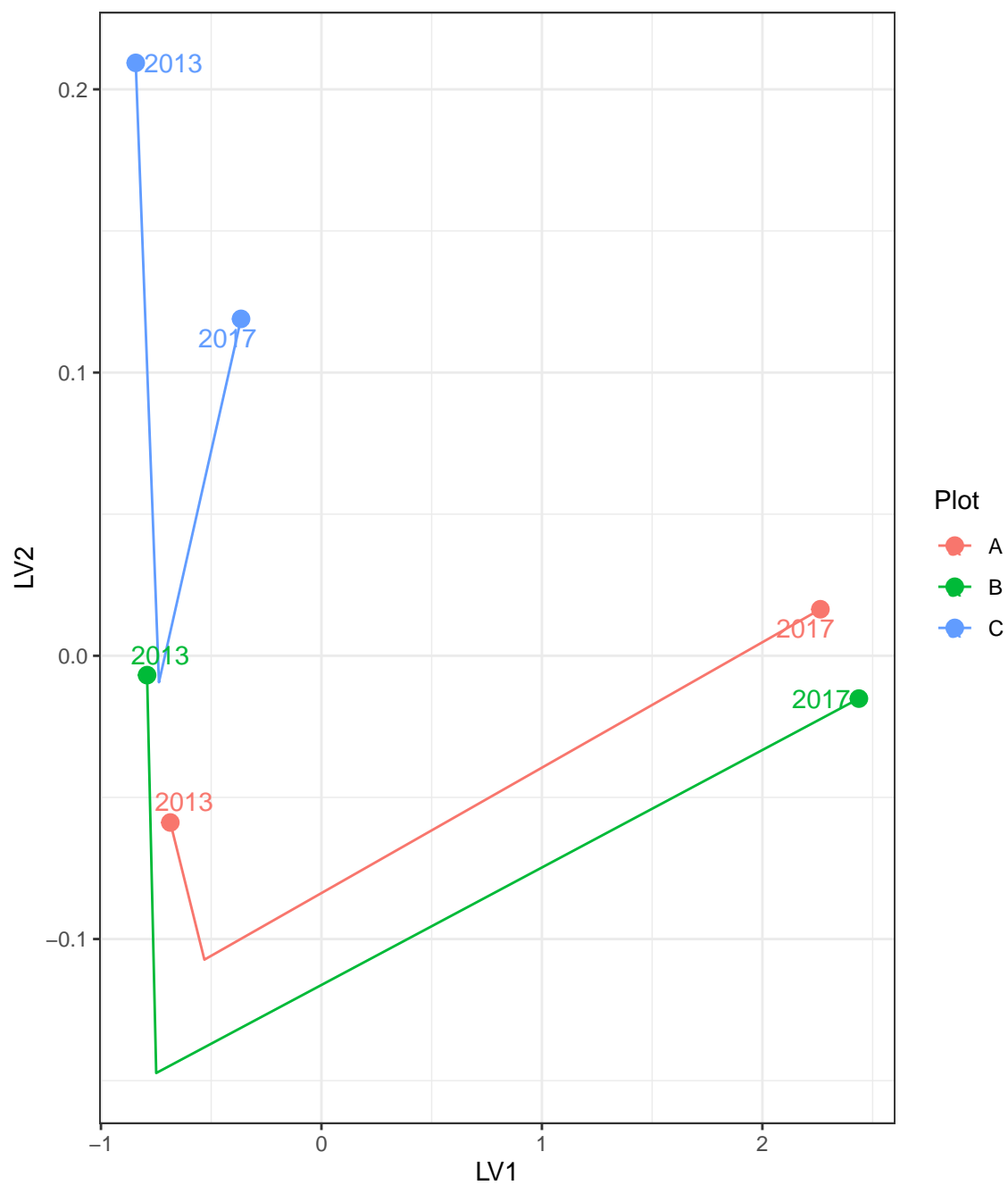


Figure 12: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

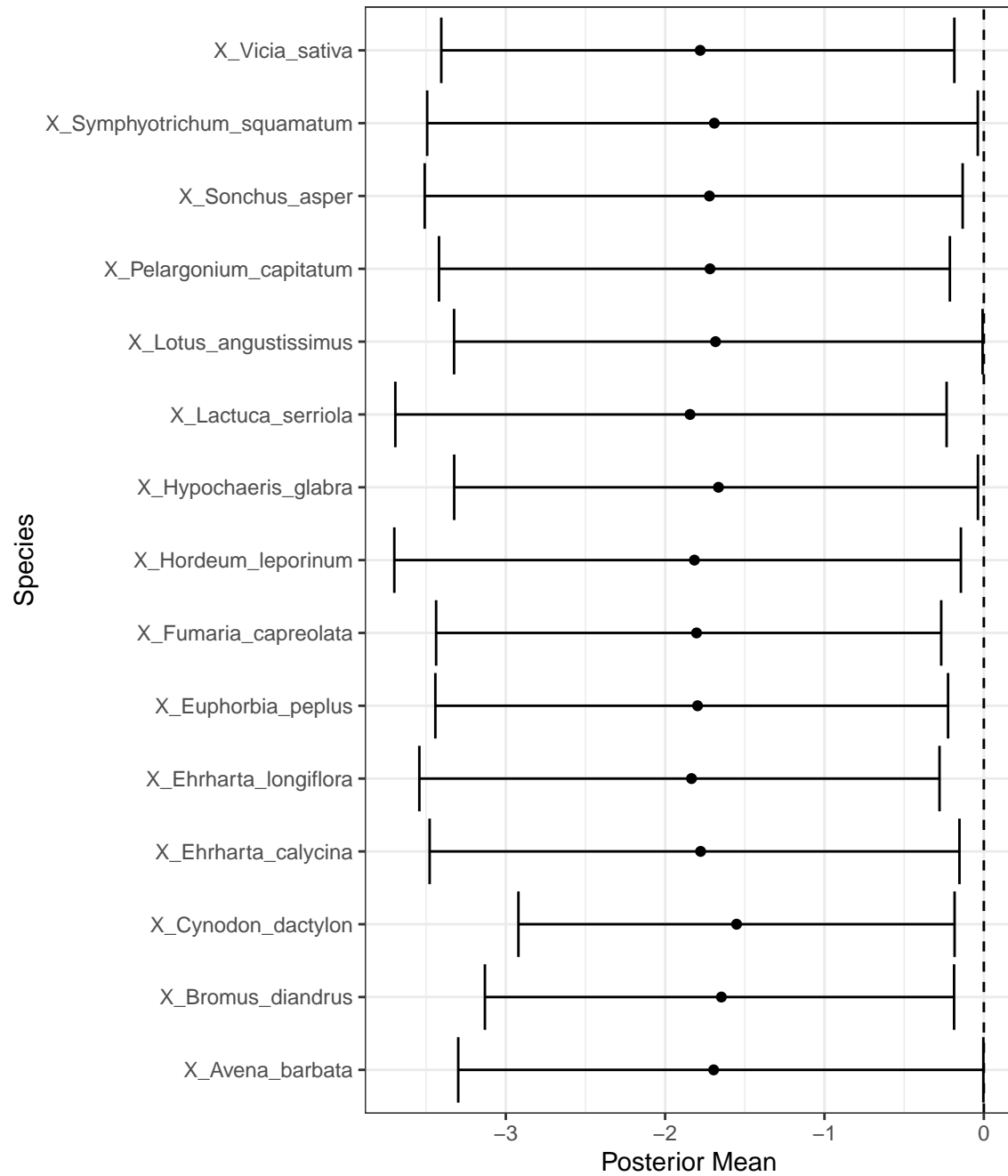
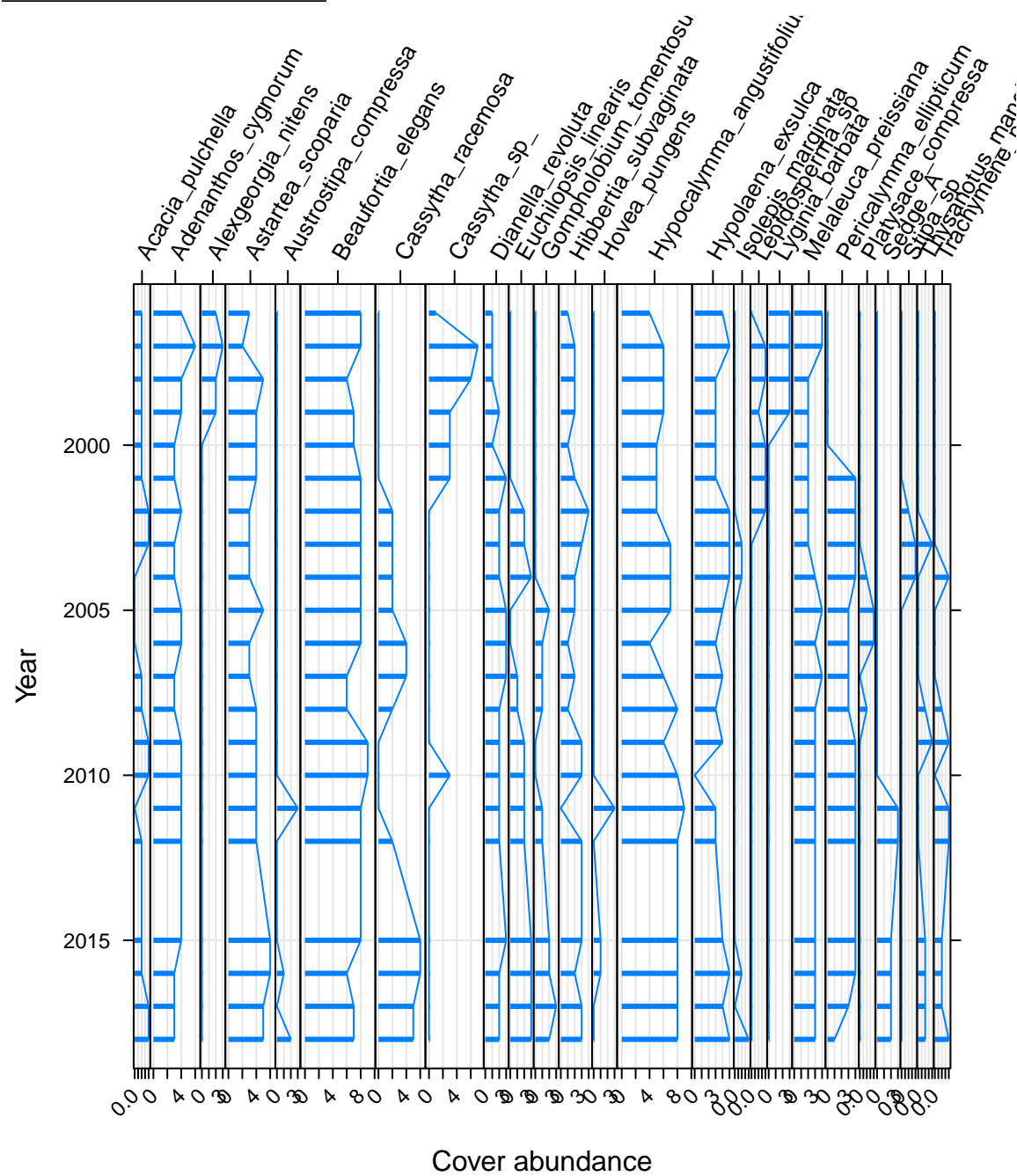


Figure 13: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

Jandabup

Five year summaries of surface water level data at Jandabup

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	44.914	44.109	0.805	October	February	155.800
08/1999 - 07/2004	44.876	44.232	0.644	September	March	151.200
08/2004 - 07/2009	44.843	44.248	0.595	July	March	108.000
08/2009 - 07/2014	44.674	44.156	0.518	October	January	164.400
08/2014 - 07/2019	44.744	44.231	0.513	September	March	182.000



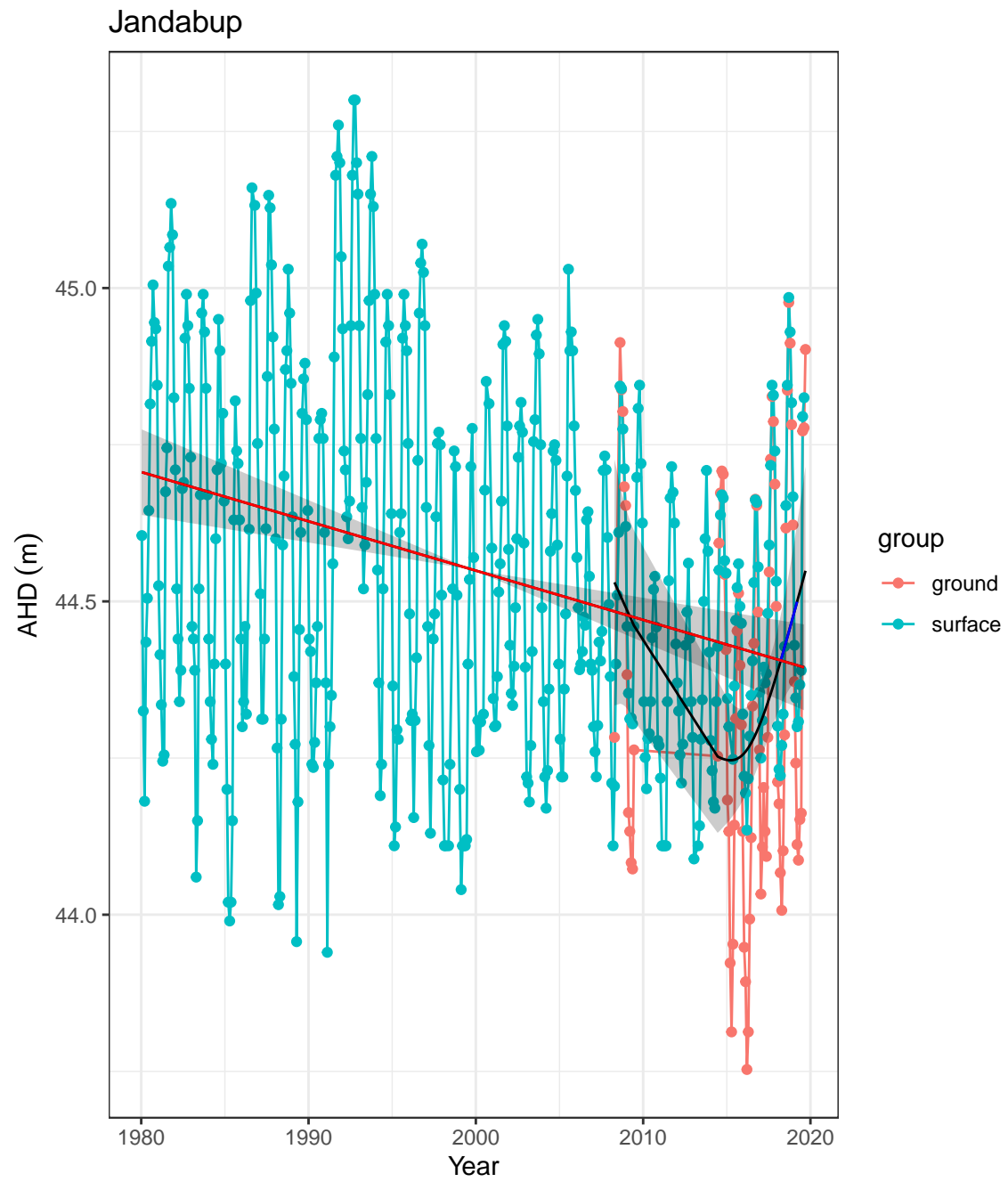
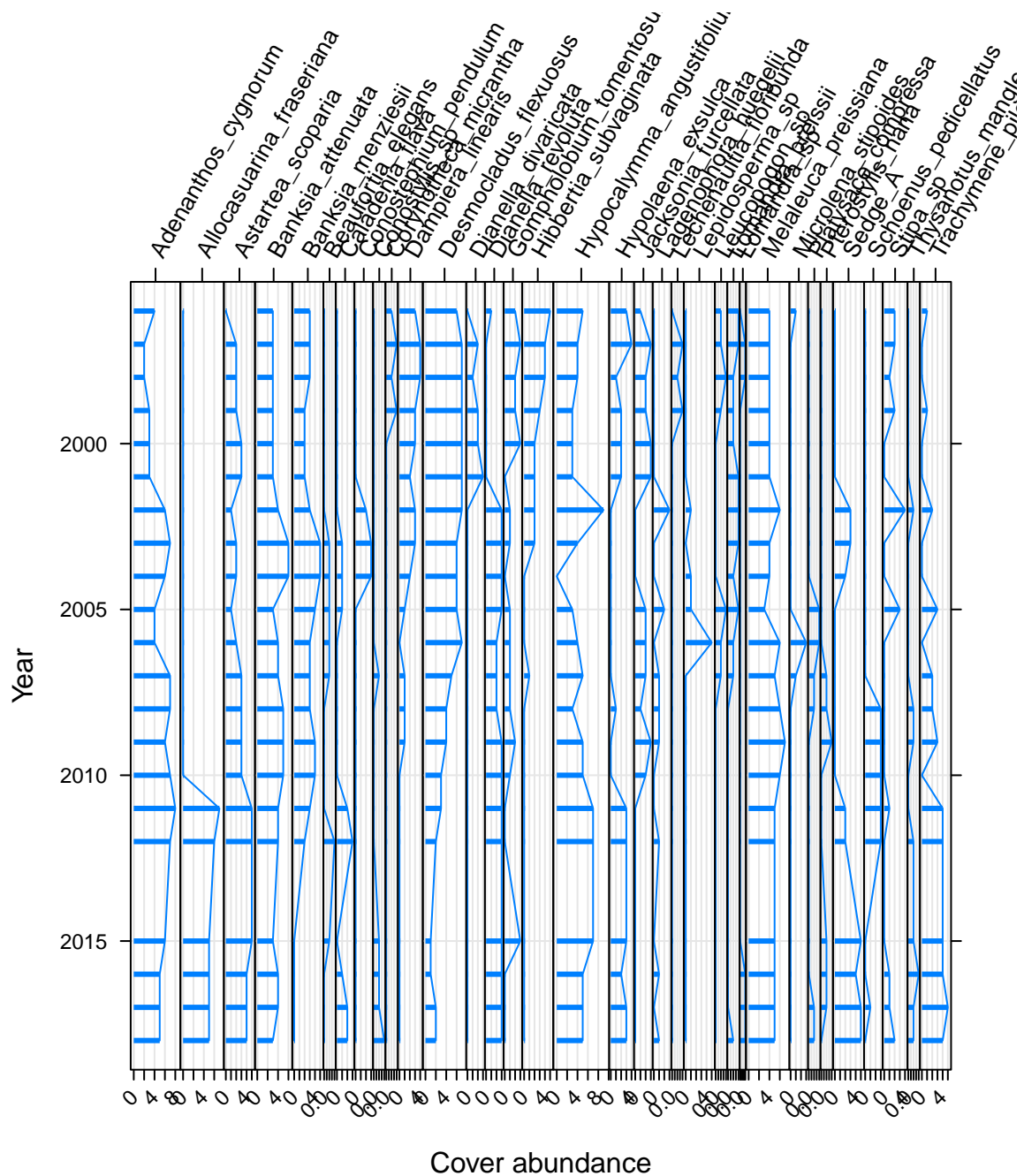


Figure 14: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Jandabup





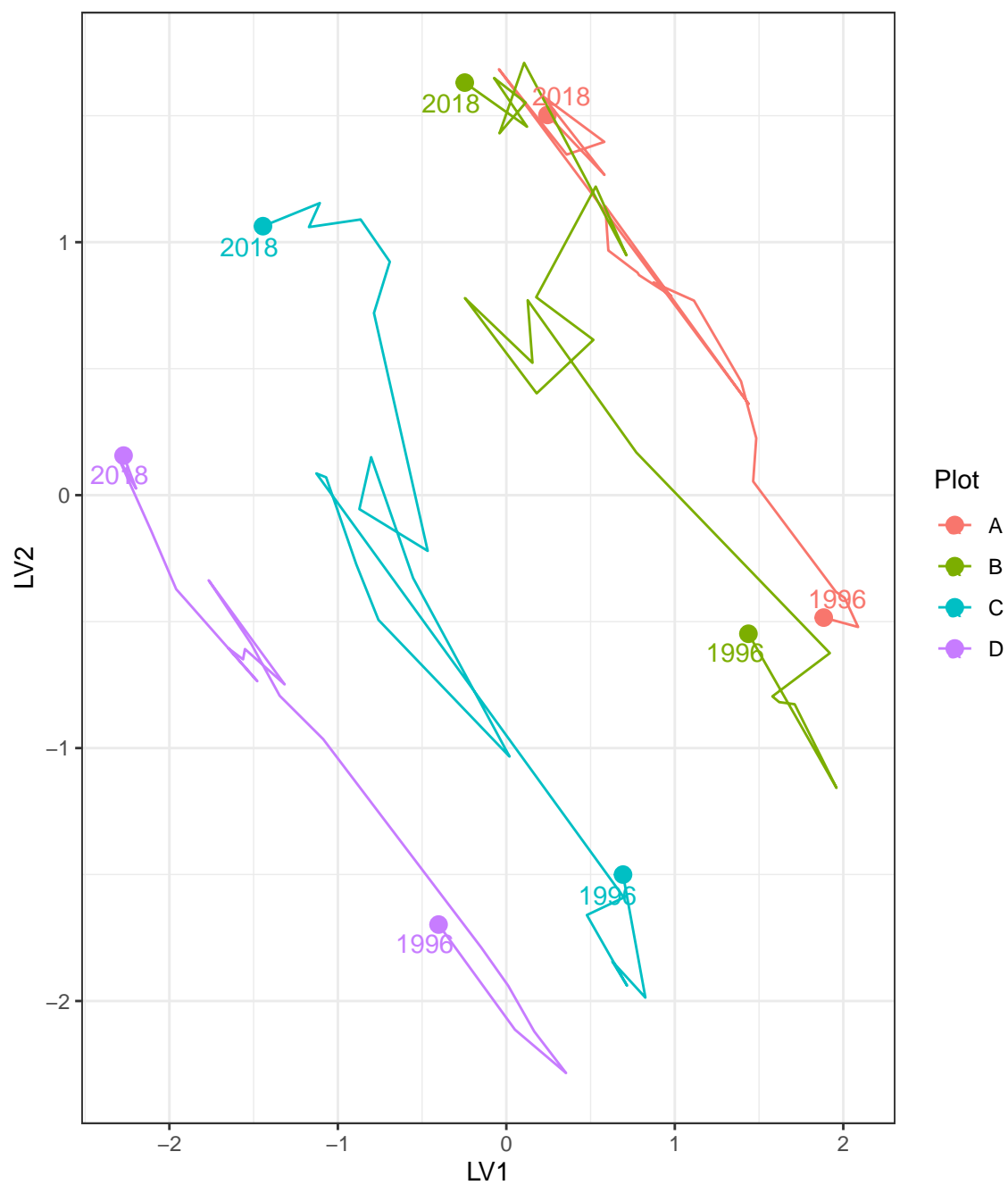


Figure 15: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

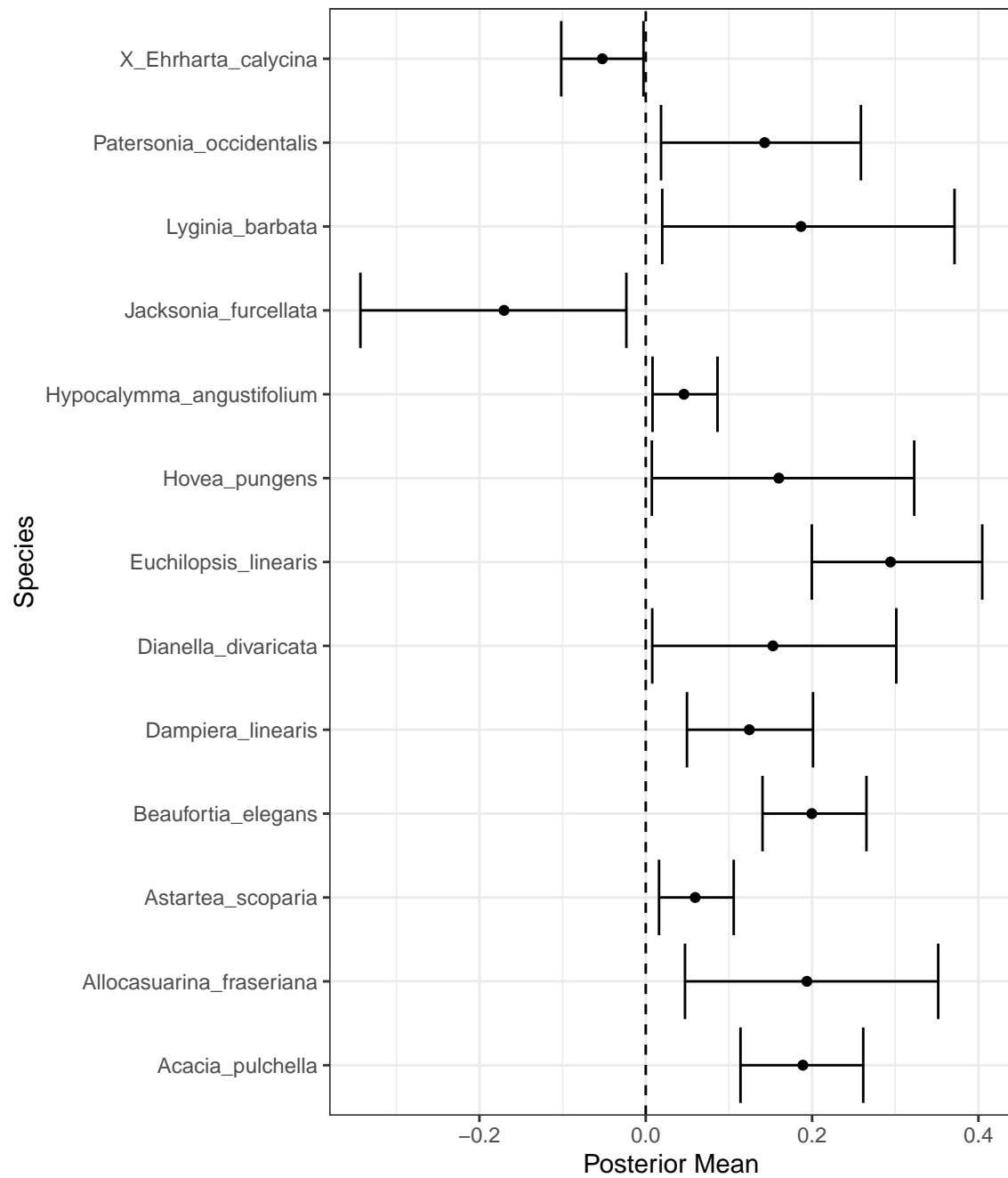


Figure 16: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

variety of significant mammal species.

Lake Joondalup has remained permanently inundated at the staff gauge [HOW DO I FIND THIS OUT] since 1986 (REFERENCE Chapter 5 Horwitz et al). However, vast regions of the basin dry most summers. Historically, groundwater levels at monitoring bore 61610661 declined significantly from 19.3 to 18.1 mAHD from 1970 to 2002 (Figure 1). Currently, groundwater levels at this bore, as well as bore 61611423 (likely to better reflect lake surface water variation), have been increasing since 2015 to levels similar to the early 1990's. Recent monitoring of surface water levels at the staff gauge 6162572 remained relatively stable from 2002 but have been increasing from 16.4 mAHD to approximately 17.2 mAHD in 2019. Five-year summaries of hydrological regimes at Lake Joondalup also reveal the higher mean minimum and maximum surface water levels in the latest period compared to earlier periods, as well as an increase in the number of days to reach seasonal minimum water levels (Table 1).

Five year summaries of surface water level data at
Lake Joondalup

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	17.184	16.225	0.959	September	April	213.400
08/1999 - 07/2004	16.980	16.064	0.916	October	April	179.400
08/2004 - 07/2009	16.916	16.123	0.792	October	April	181.000
08/2009 - 07/2014	16.884	16.064	0.820	October	March	172.800
08/2014 - 07/2019	17.162	16.483	0.679	October	April	205.800

The recent increases in surface water levels has increased the pH from 6.8 in 2016 to 8.4 in 2018 and increased alkalinity to 206 mg/L. Recent nutrient levels have been decreasing. [I NEED THIS DATA TO ANALYSE TRENDS] Vegetation surveys have been conducted along two transect at Lake Joondalup (Figure 2 and 3). Both the northern and southern transects were established in 1996 and were last surveyed in 2015. *Melaleuca raphiophylla* dominates the overstorey of plots in the northern transect while exotic species are abundant in the understory vegetation. There has been an increasing trend in cover abundance of the exotics *Bromus diandrus*, *Ehrharta longiflora*, *Euphorbia terracina*, *Fumaria muralis* and *Peargonium capitatum* in recent years. Fires in 2003 reduced the canopy condition and abundance of *M. raphiophylla* in the southern transect, and despite the slightly higher cover abundance of native species, native and exotic species richness is equal along the transect. The site also contains healthy stands of *Baumea articulate* and *Centella asiatica* in the submerged regions of the transect.

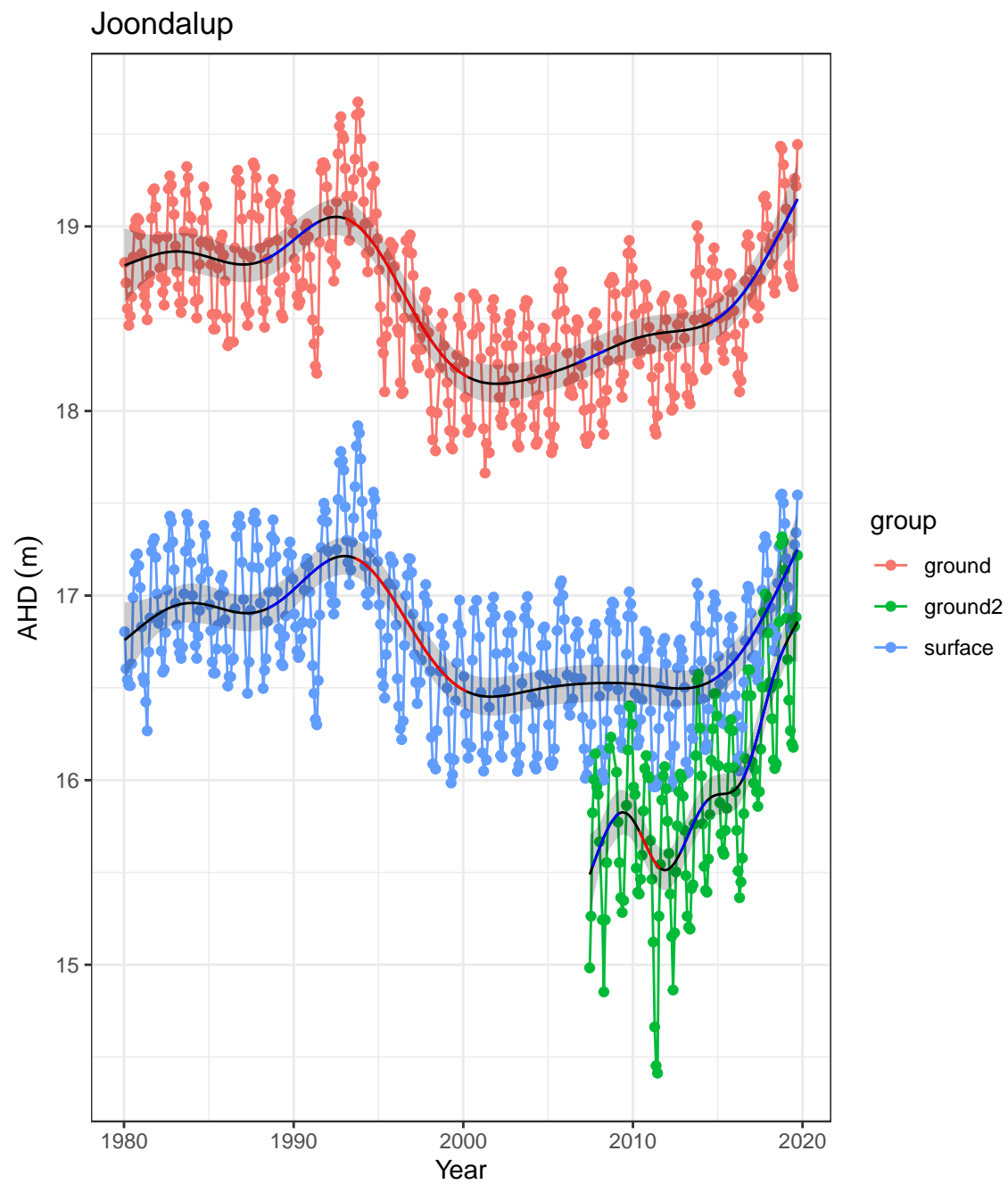
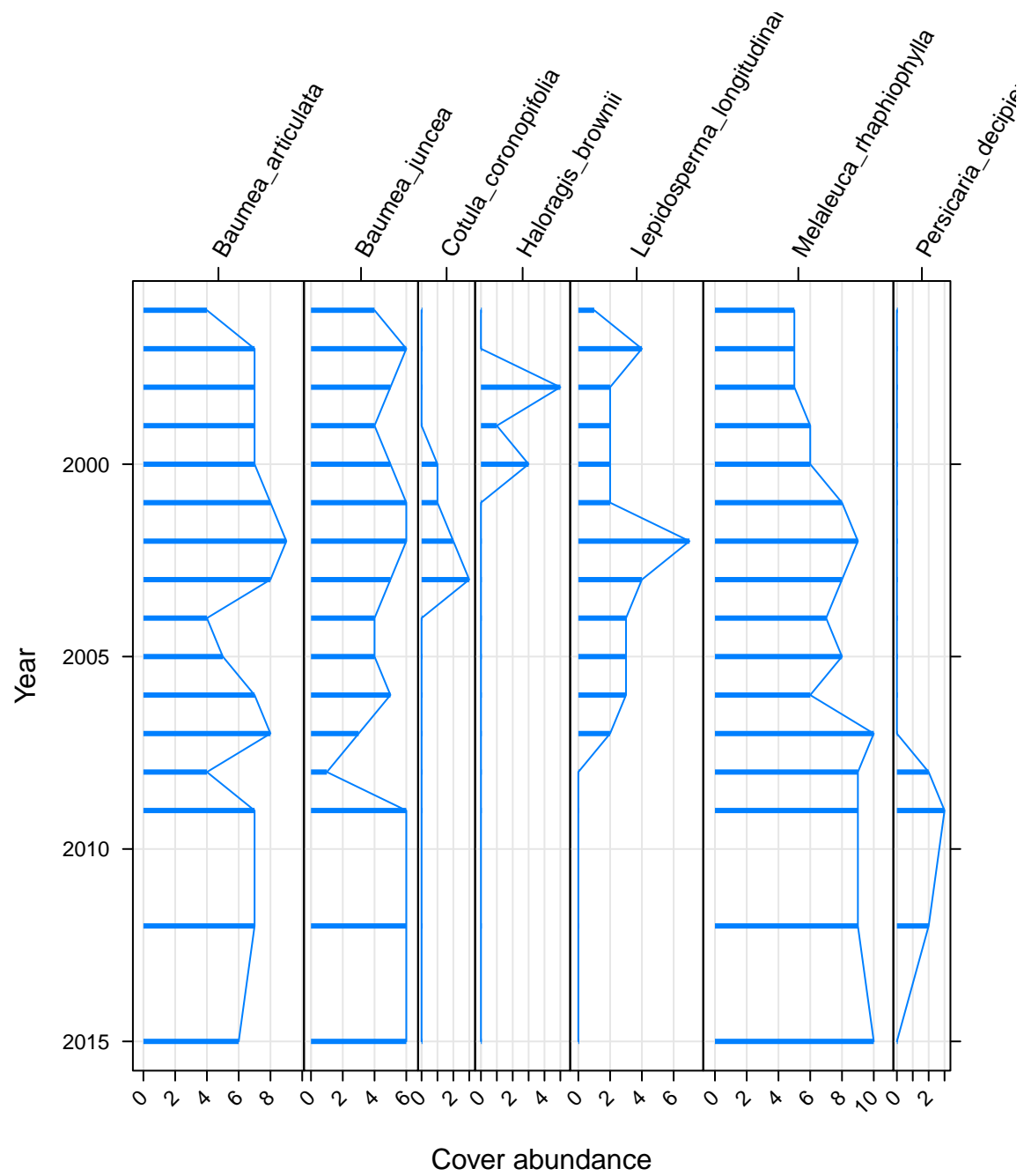
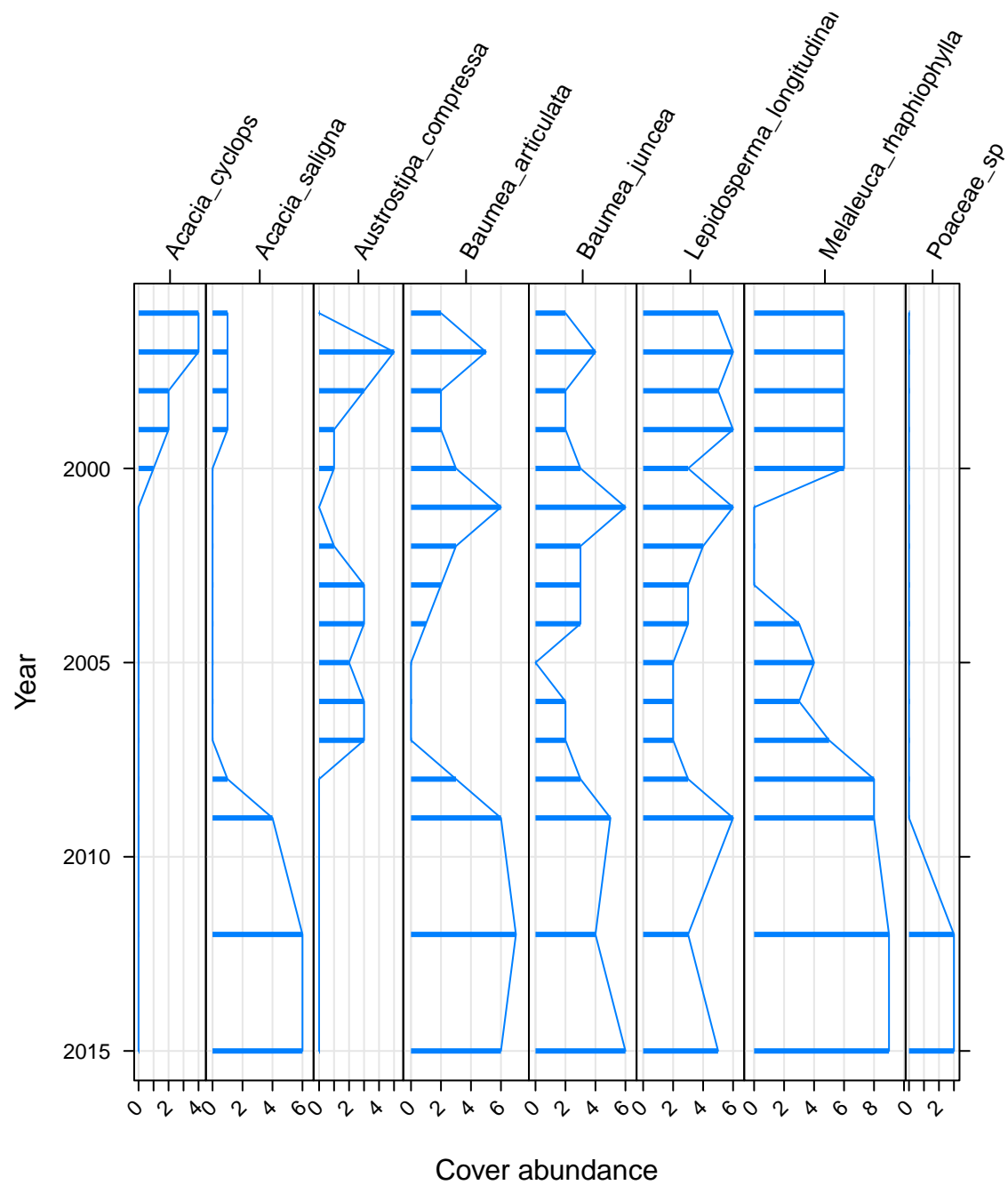
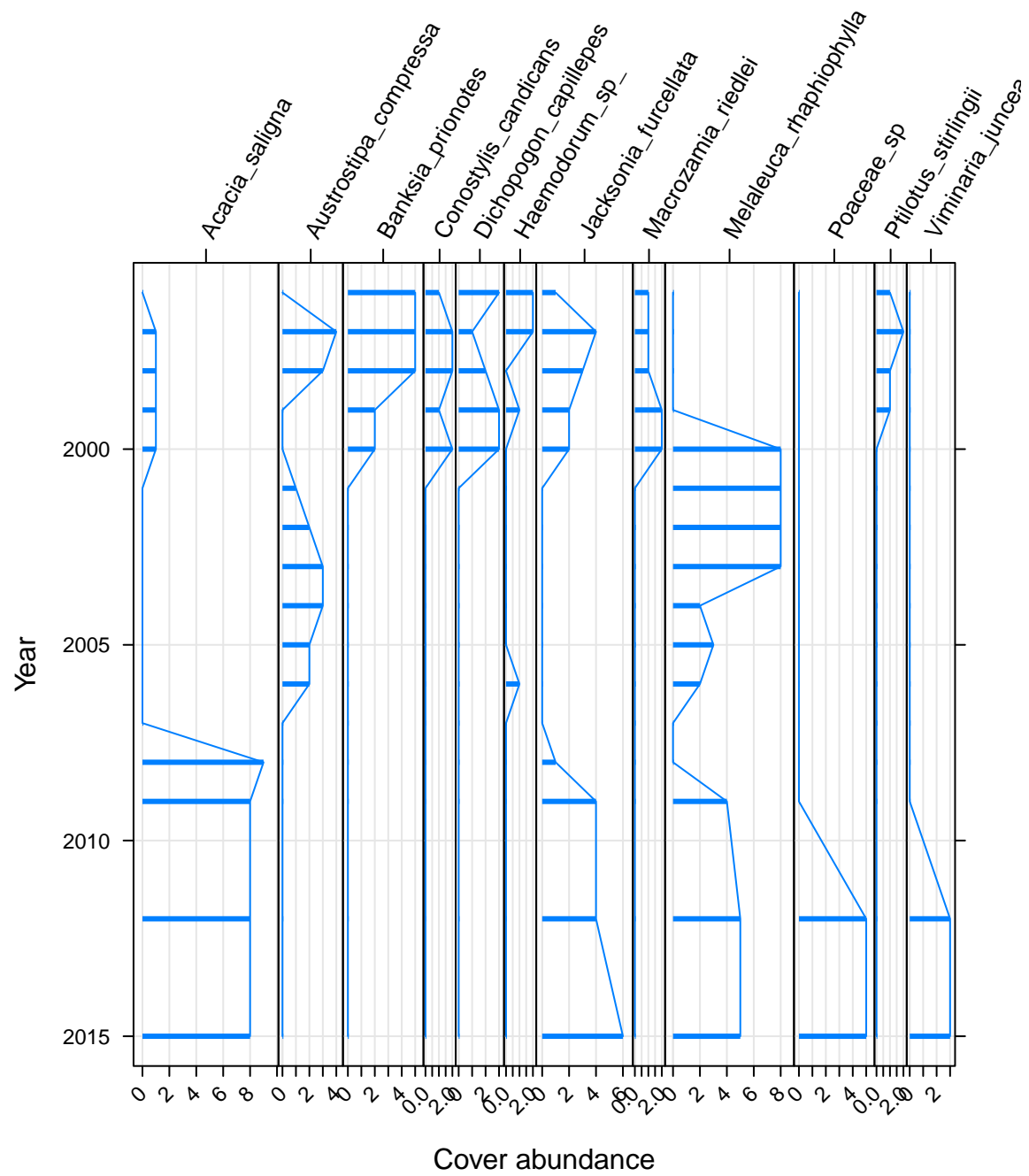
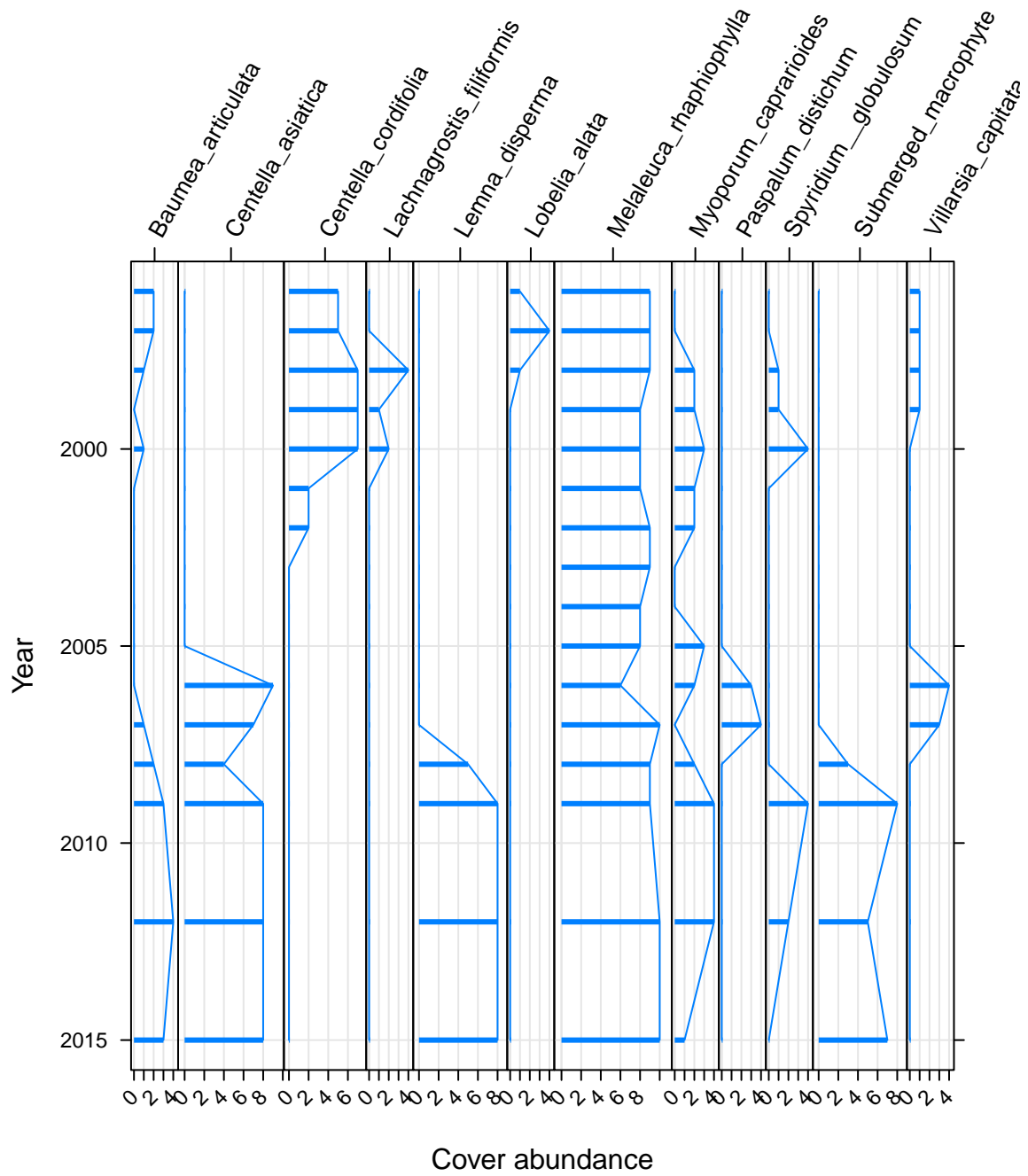


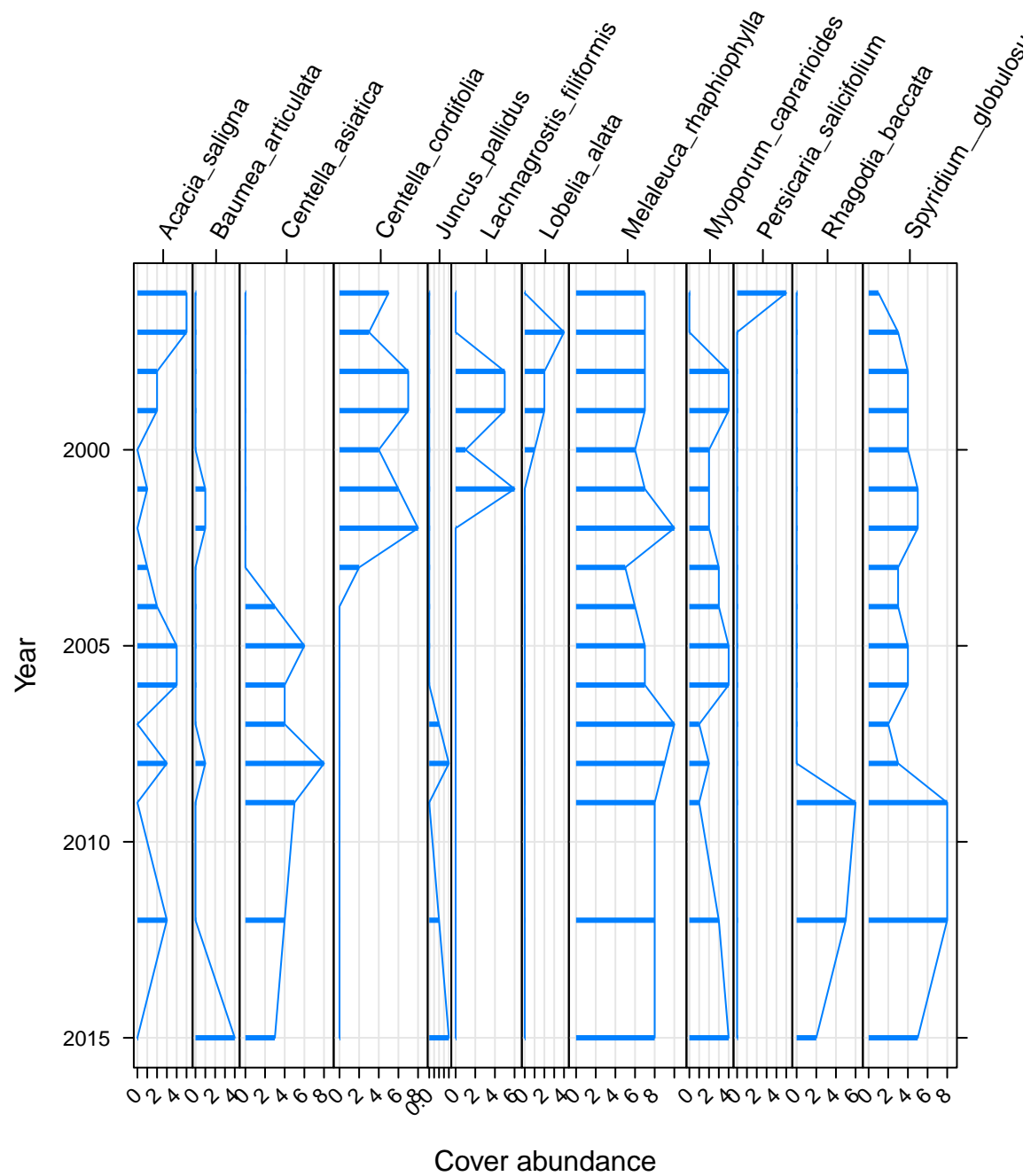
Figure 17: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Joondalup

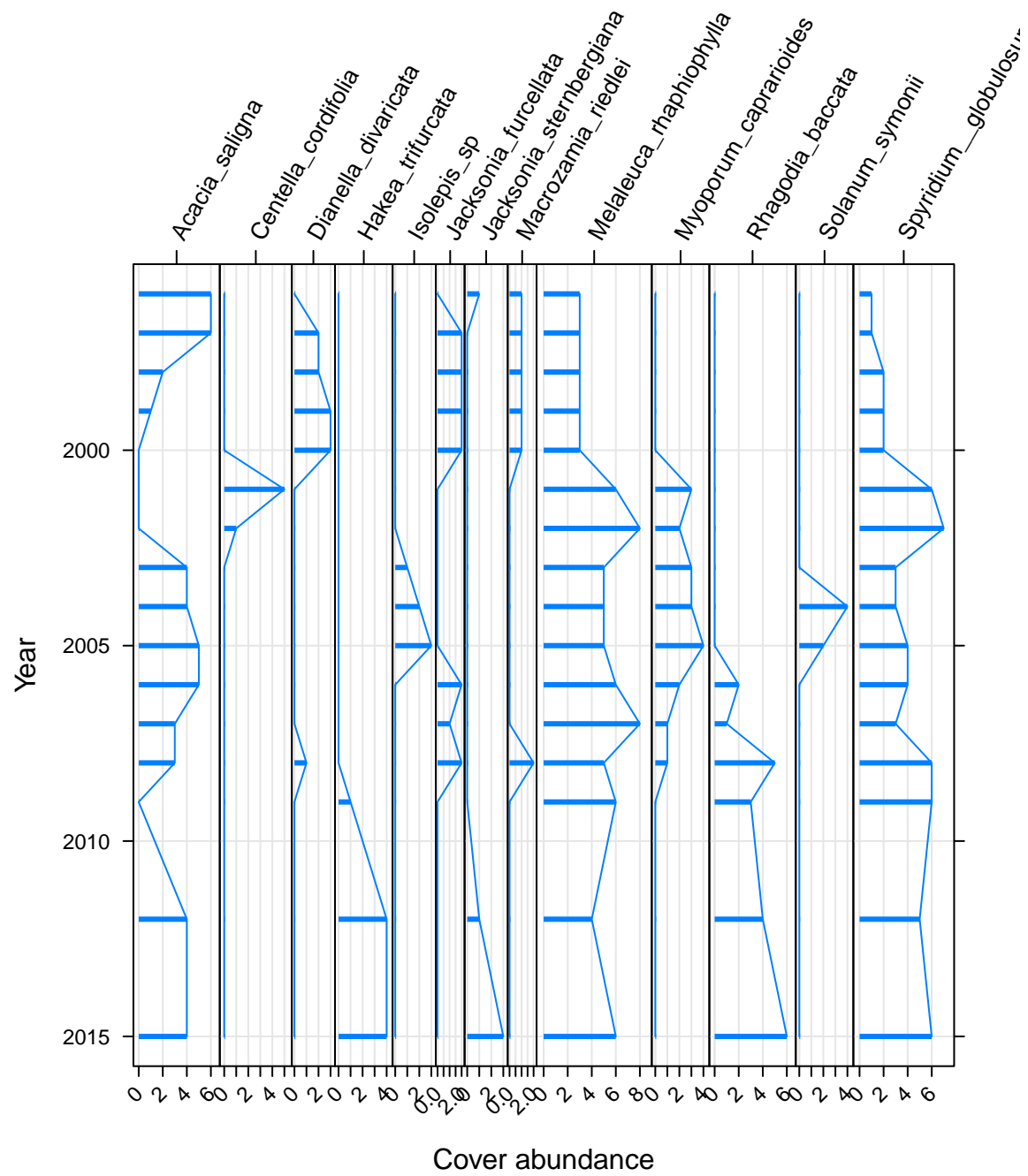


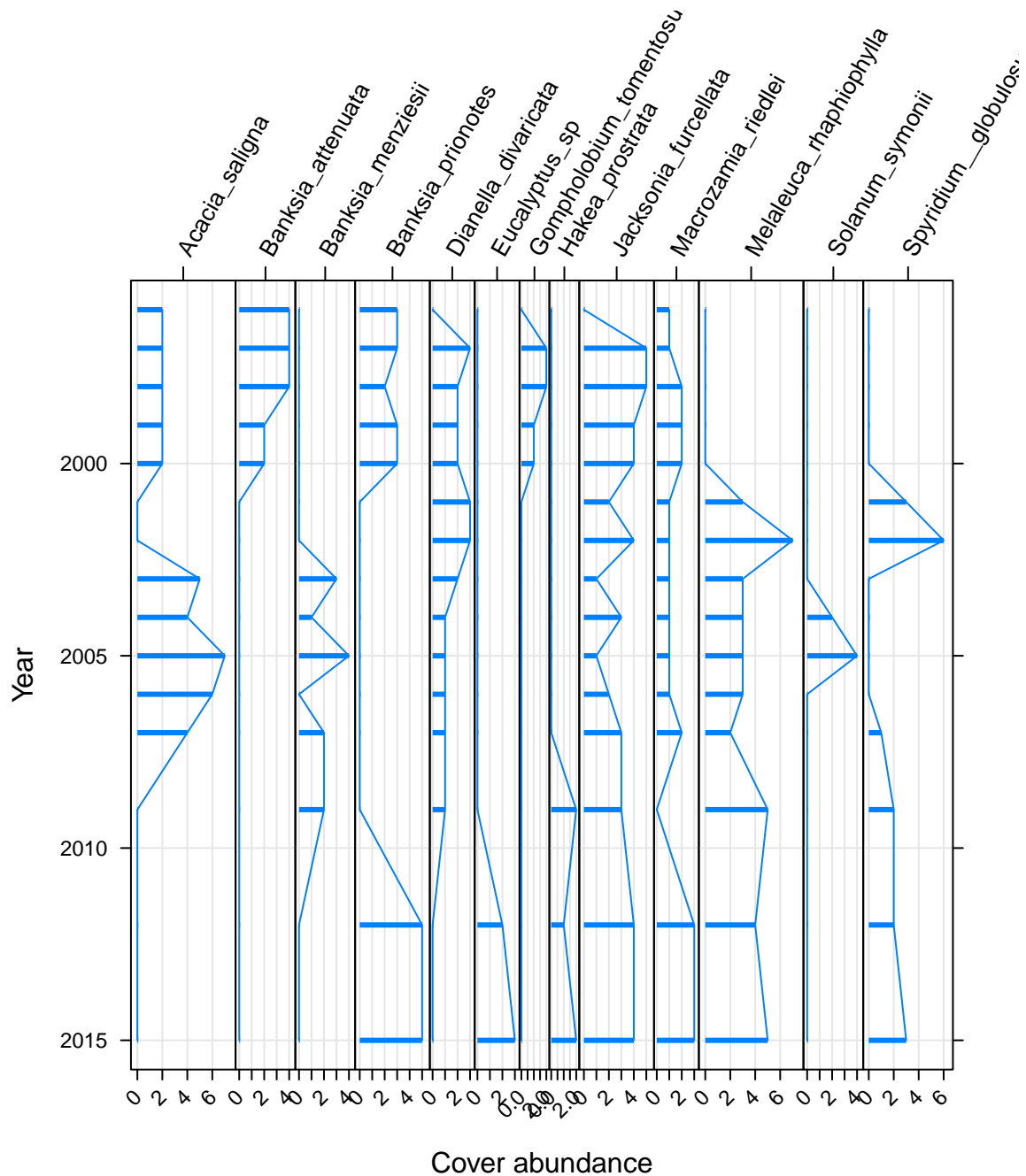












All plots in both transects have displayed similar trends in community compositional change during the survey period. In the southern transect, latent model ordination reveals separation of the plots along the first axis, with a general increasing temporal trend along the second axis, except for a period around 2003 ? 2006 where there was a hiatus (Figure 4). This hiatus in change would be associated with the 2003 bushfire and represents the recovery period. The trajectory for plot A is different, however, as the trend away from the original 1996 survey has reversed and the contemporary community is now becoming more like the 1996 communities. When the ordination model was re-run accounting for fluctuations in groundwater levels as a co-variate, the pattern of change in community trajectories remained unchanged, suggesting that these shifts have not been greatly influenced by groundwater levels. A similar temporal shift was observed in the northern transect, where the contemporary plot A has returned to a composition similar to the 1996 survey (Figure 5). Changes associated with groundwater fluctuations are also weak, with ordination accounting for

groundwater levels displaying similar patterns to the full residual model. The proportion of native species has generally remained below 50% for both transects since 2009 (Figure 6 & 7).

Aquatic invertebrates have been sampled from Lake Joondalup every year since 1996. During this period, 16-30 families of aquatic invertebrates have been recorded per sampling event, except for the latest round in 2018 where family richness was only nine. This exceptionally low family richness was likely due to the lack of insects and associated parasitic mites among the sampled communities. The phreatoicid isopod *Amphisopus palustris* was also absent in 2018 despite being collected every spring in Lake Joondalup (expect 2004). Furthermore, this reduced richness occurred during a period of relatively high surface water levels, suggesting other anthropogenic factors may be responsible for the decline of insect fauna within the lake. Otherwise, the lake hosts abundant populations of *Ceinidae* (amphipods), *Palaemonetes australis* (crustacean), *Calanoid* copepods and *Cyprididae* (ostracods). [ANALYSE INVERTS HERE]

Future predictions [Insert plot of future changes in groundwater]

The water levels in the vicinity of Lake Joondalup are expected to increase by 2.1m by 2030 from 2013 levels based on the revised groundwater allocations. This increase in water level will continue the increasing trend being observed in the lake's surface water levels since 2015. Maintaining surface water levels above 16.2mAHD at staff 6162572 will ensure permanent water habitat for fauna and flora and the visual amenity of the area. The diverse macrophytes inhabiting plot A and B of both transects are likely to persist and continue to provide a rich habitat for aquatic vertebrates. Although important native macrophytes and wetland species are likely to continue at relatively high cover abundances under the future scenario, there is a high proportion of exotic taxonomic richness at these sites that the model presented here does not associate with groundwater levels. The contribution of exotic species is likely associated with climatic factors and landscape changes and under the 2030 proposed groundwater thresholds, they will likely to continue contributing a large proportion of the taxonomic richness to the Lake Joondalup vegetation community. Further vegetation monitoring is required at these transects to determine vegetation compositional changes since 2015 to understand if the trajectory in compositional change is continuing.

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Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	3.169	1.831	1.337	September	May	212.600
08/1999 - 07/2004	2.770	1.794	0.976	October	March	167.800
08/2004 - 07/2009	2.386	1.996	0.390	September	November	11.800
08/2009 - 07/2014	1.981	1.000	0.981	October	July	87.800
08/2014 - 07/2019	1.967	1.000	0.967	September	January	124.400

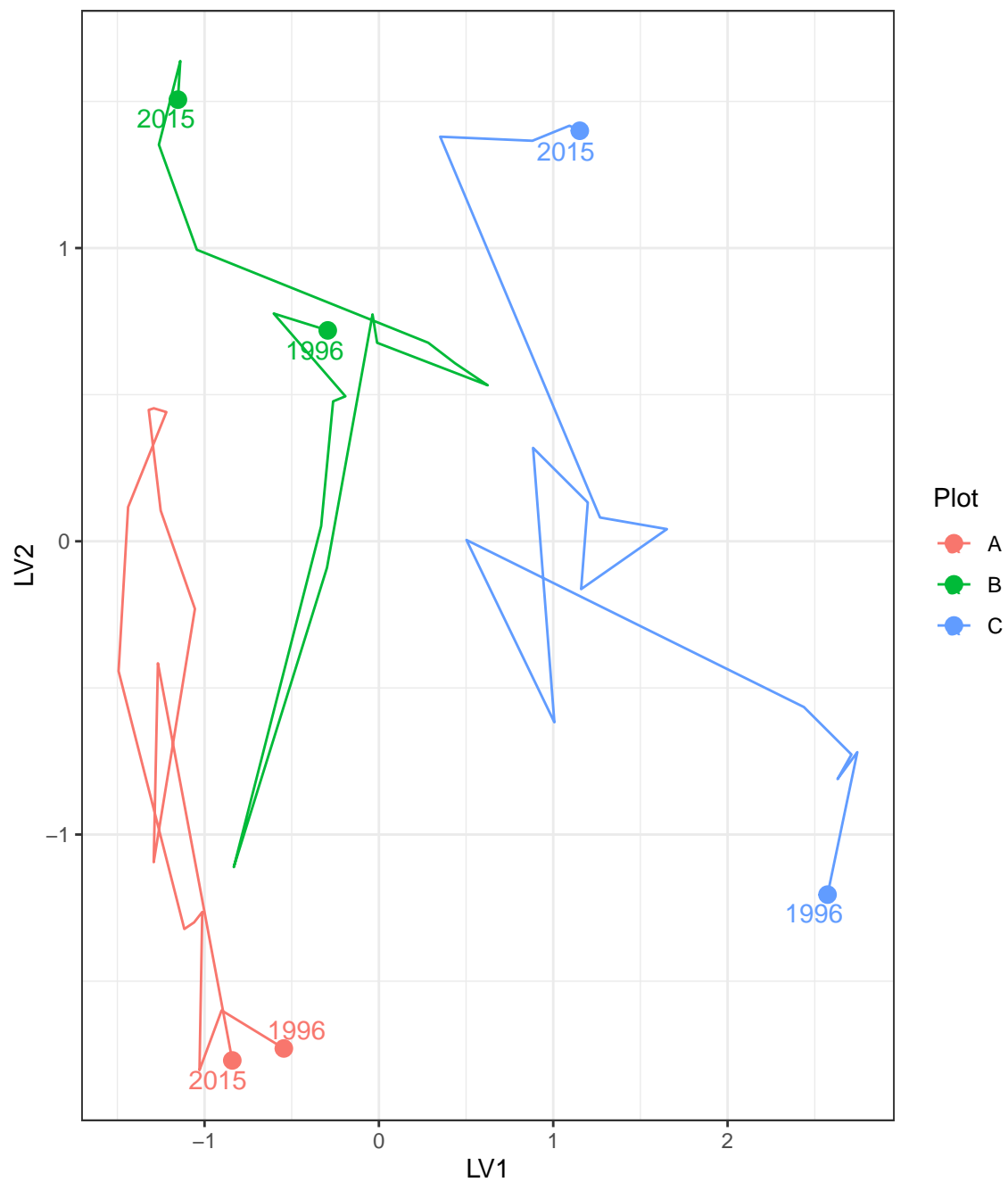


Figure 18: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for at the northern Joondalup transect

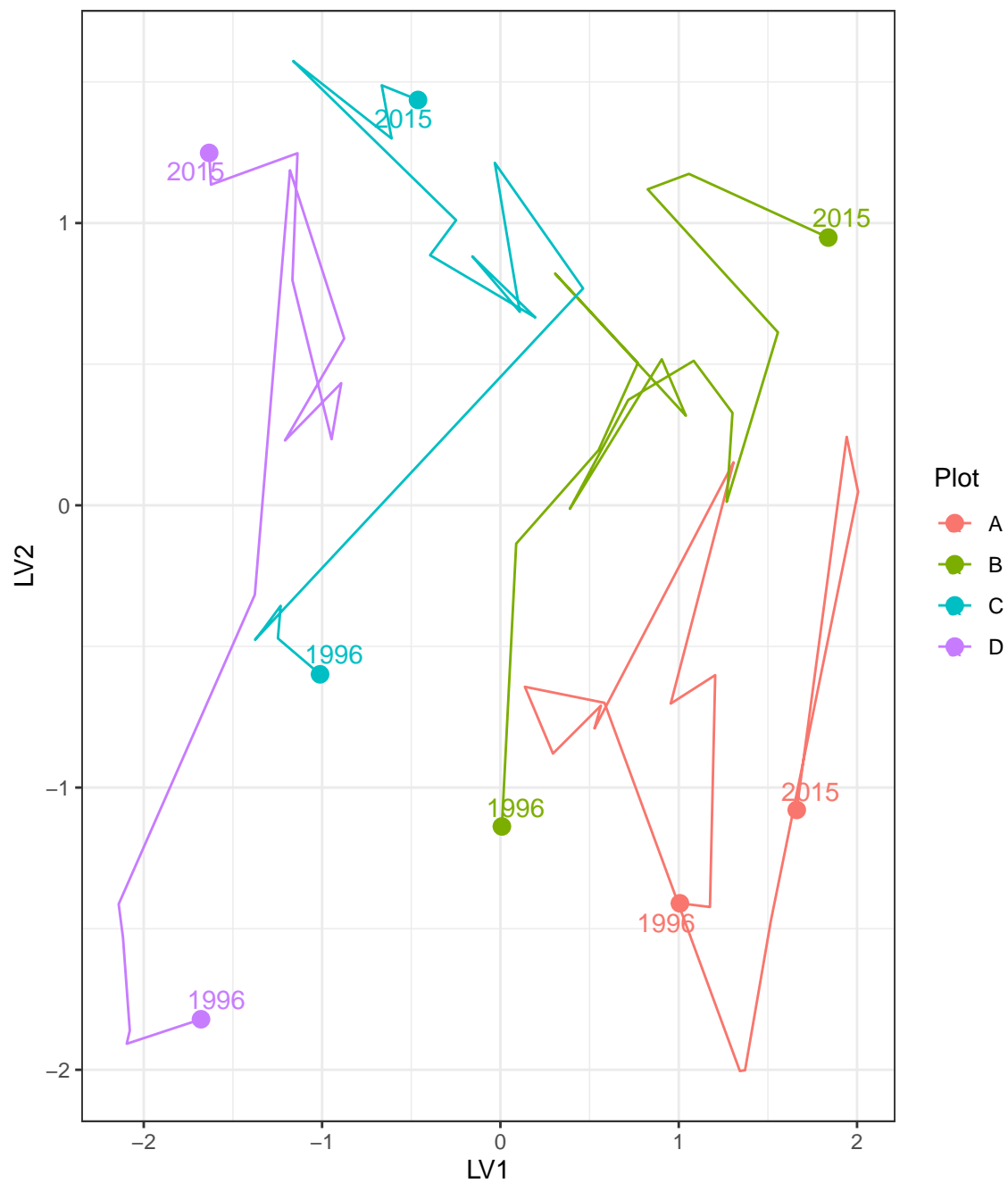


Figure 19: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for at the southern Joondalup transect

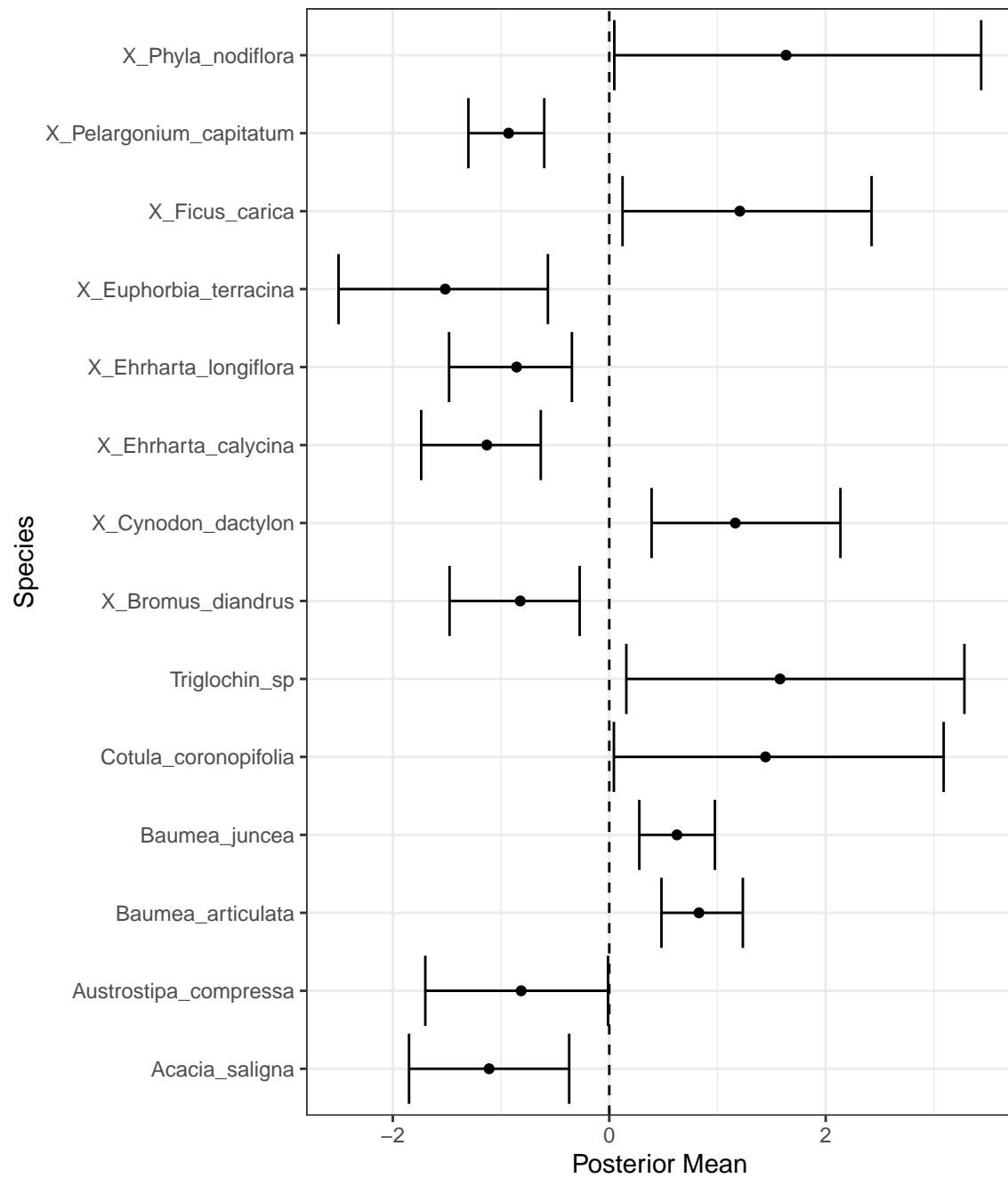


Figure 20: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

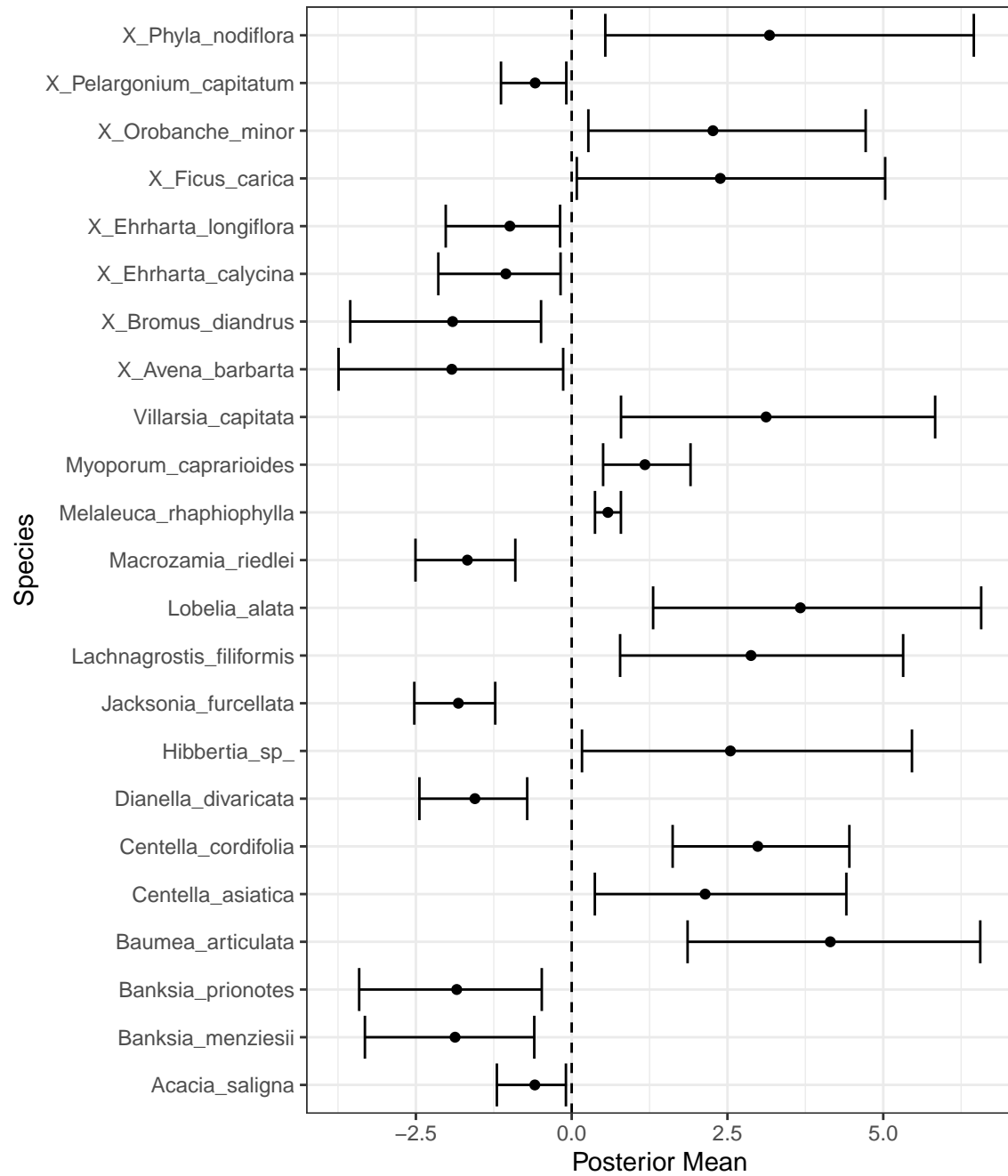


Figure 21: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

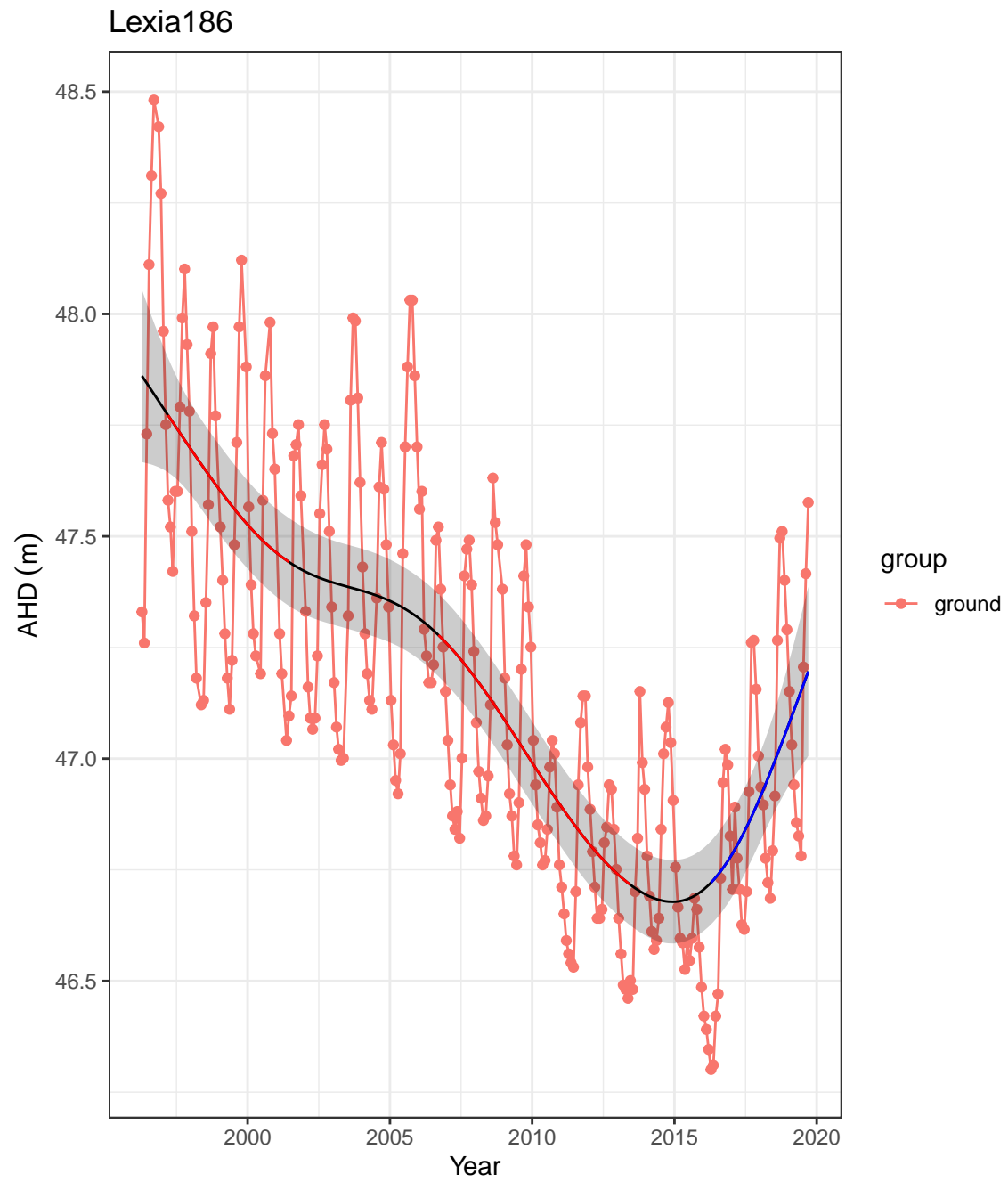
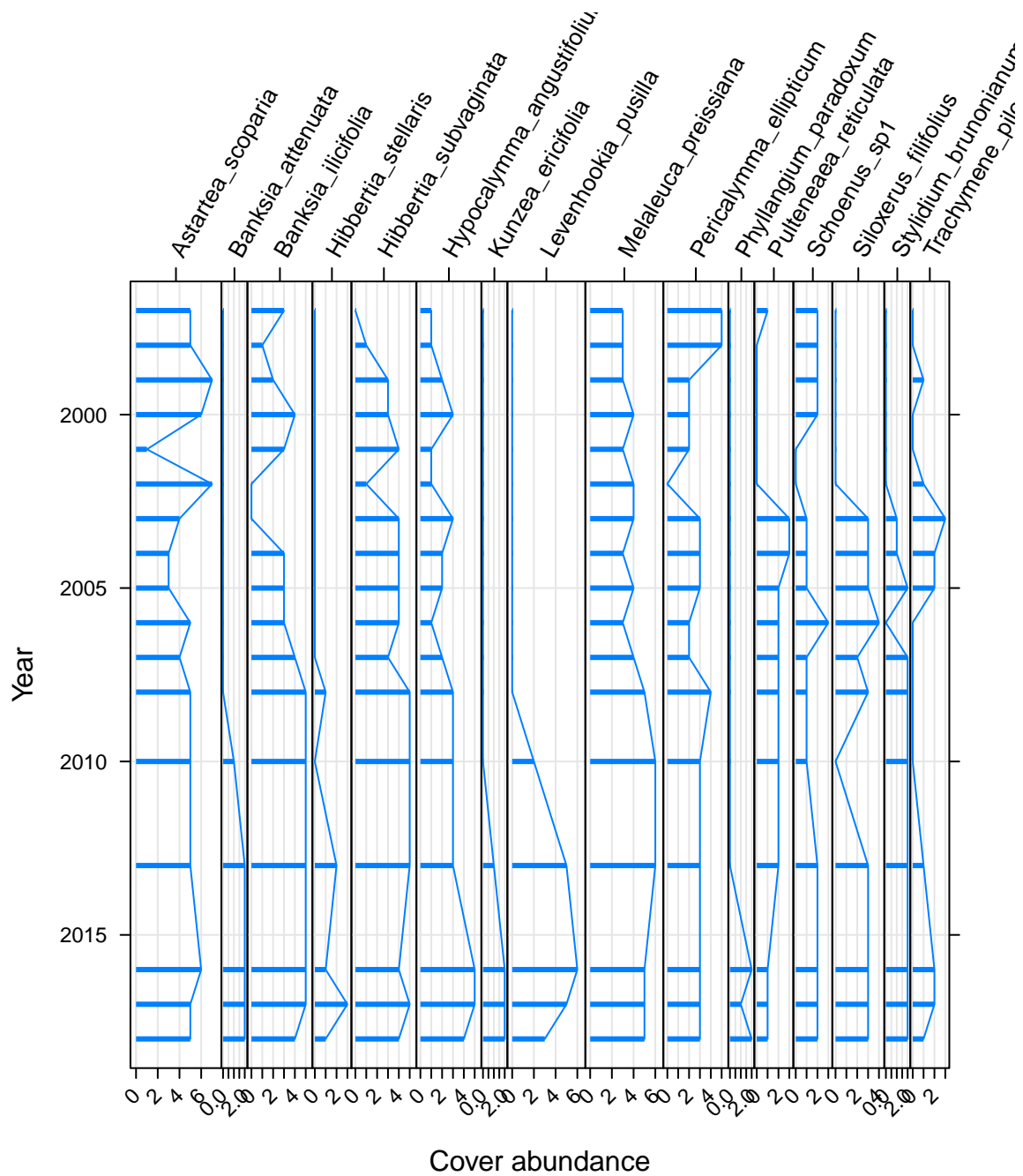
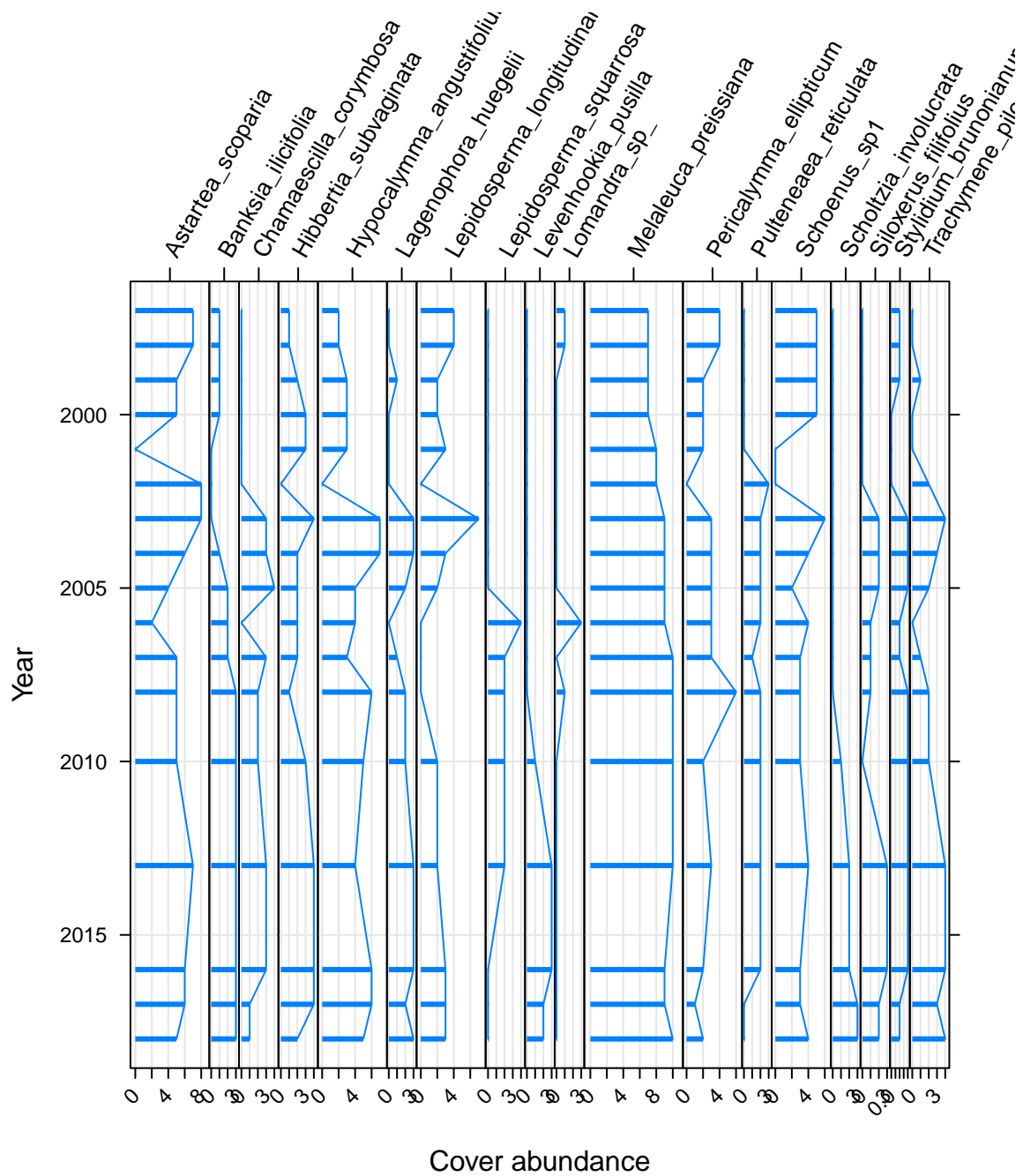
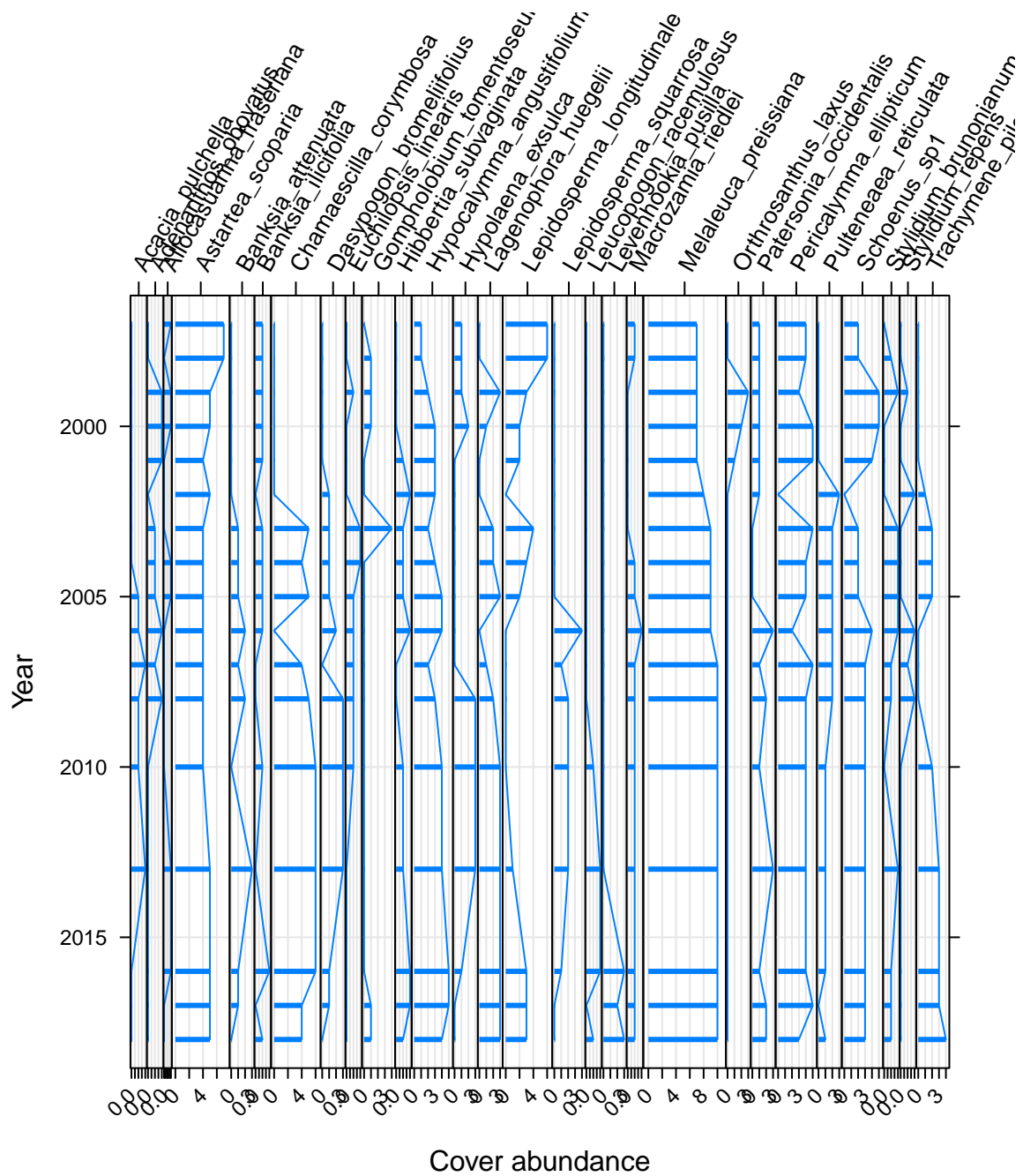
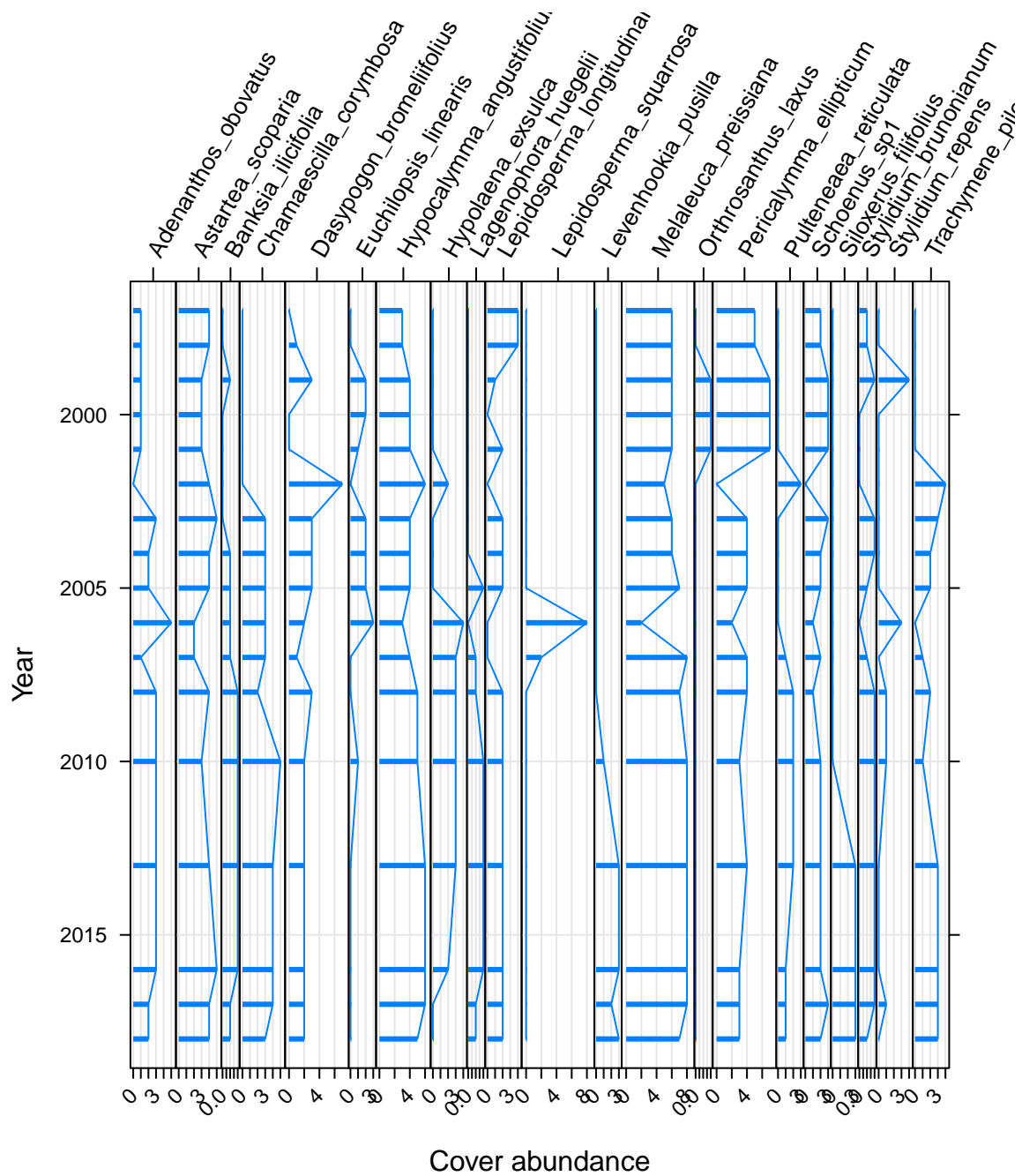


Figure 22: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Lexia 186









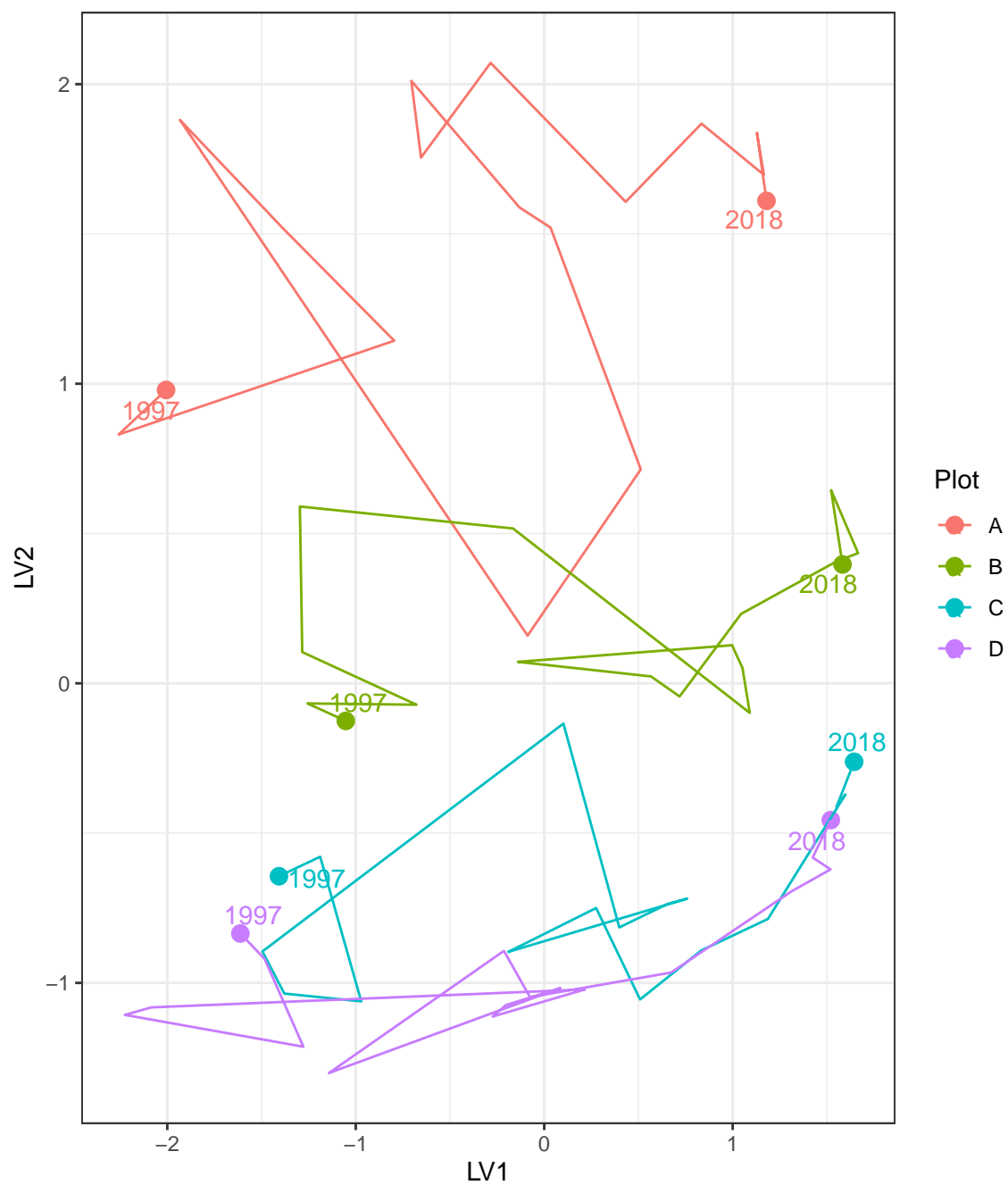


Figure 23: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

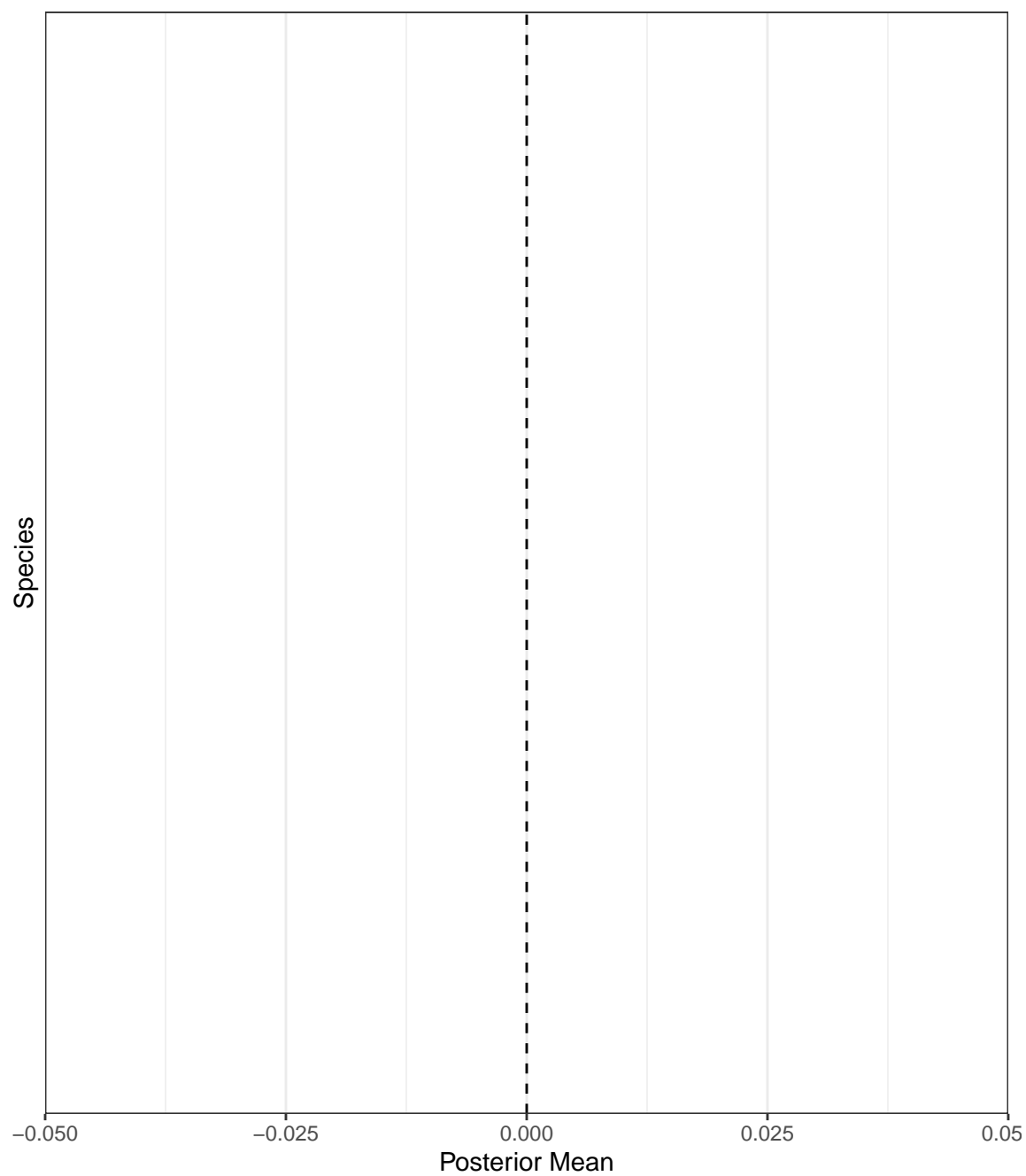
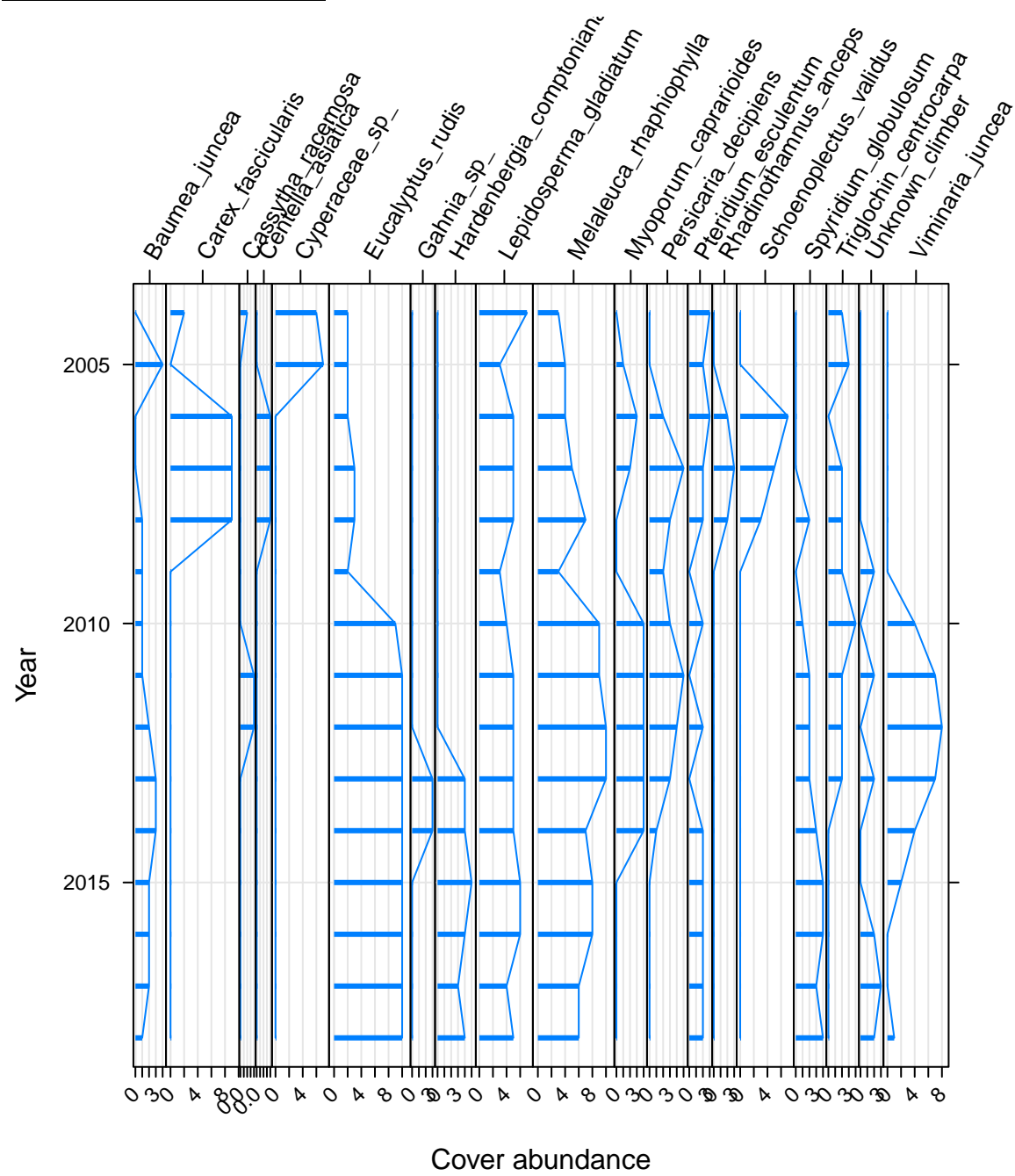


Figure 24: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

Loch McNess

Five year summaries of surface water level data at Loch McNess

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	7.107	6.997	0.110	September	March	123.200
08/1999 - 07/2004	7.067	6.944	0.123	July	March	91.000
08/2004 - 07/2009	6.969	6.762	0.207	June	February	131.200
08/2009 - 07/2014	6.532	6.220	0.312	October	May	229.000
08/2014 - 07/2019	6.250	6.140	0.110	December	July	25.000



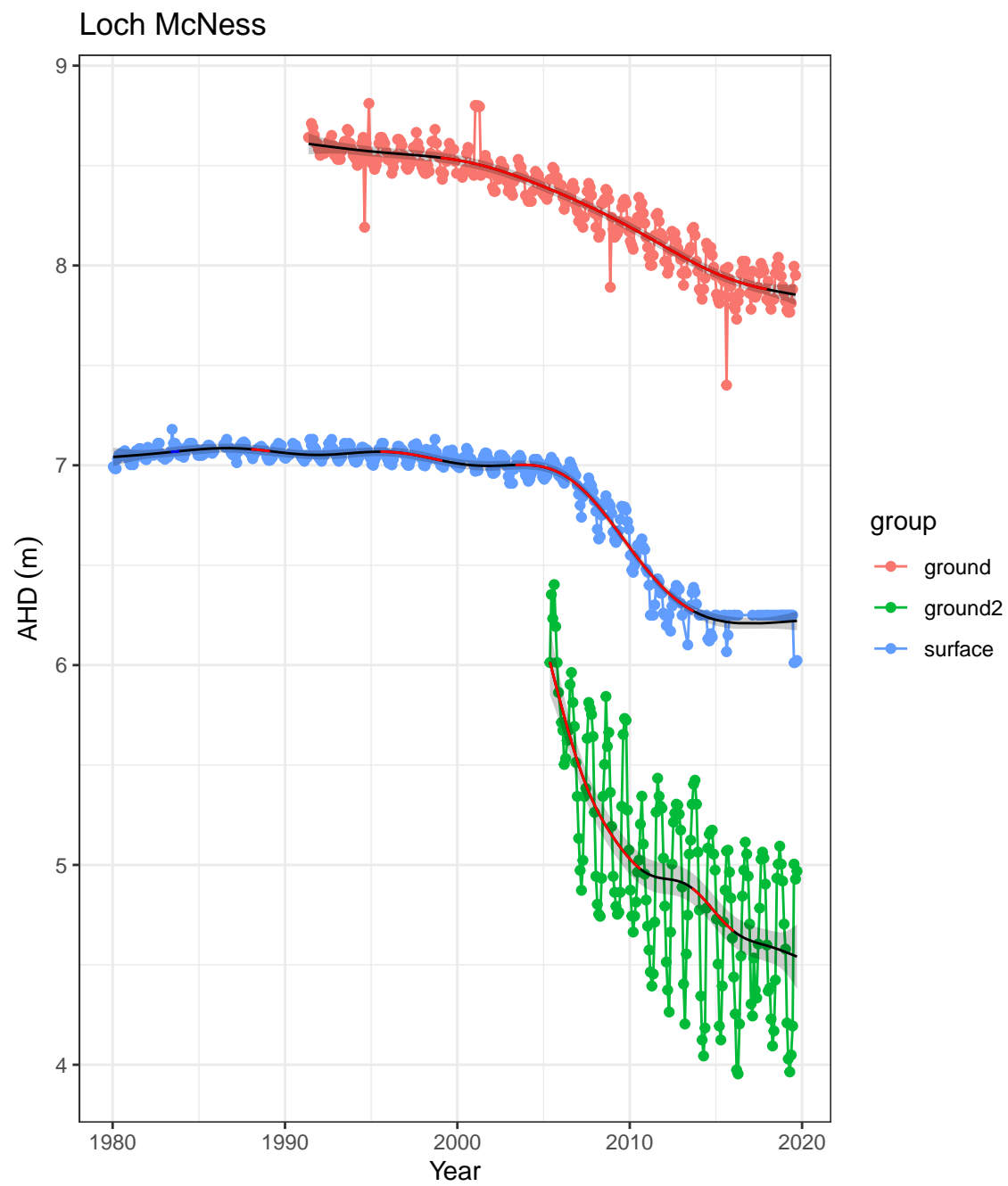
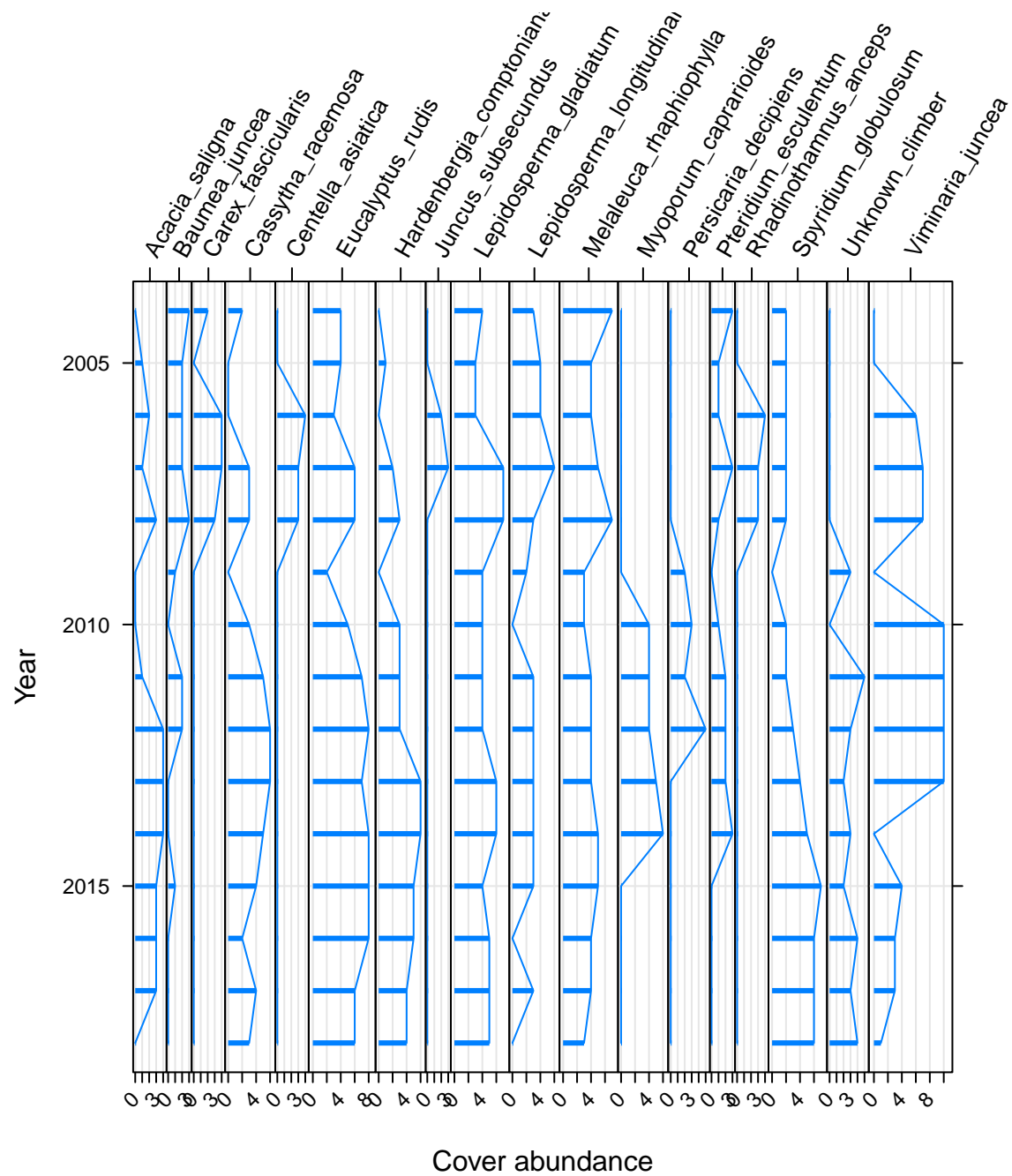
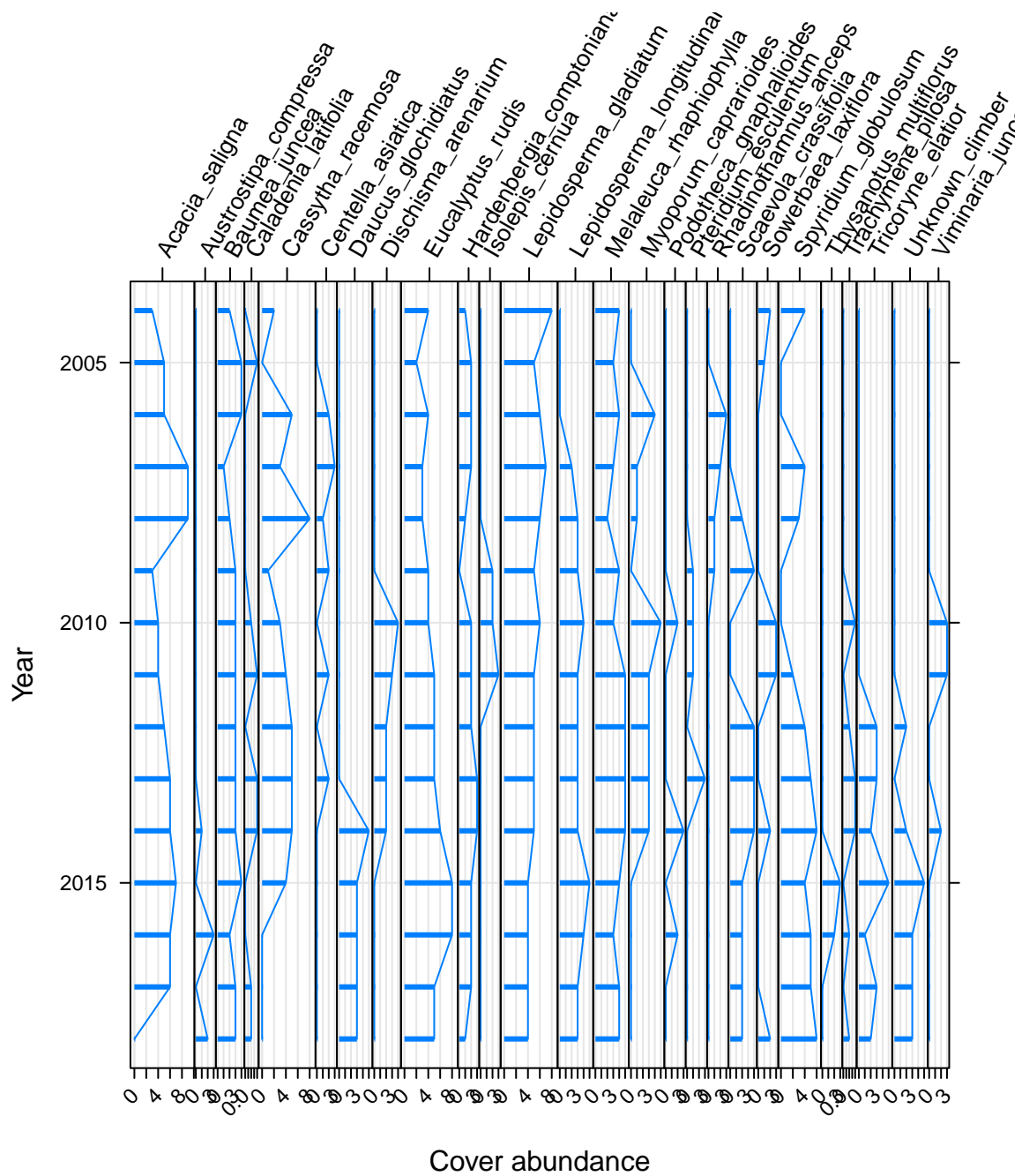
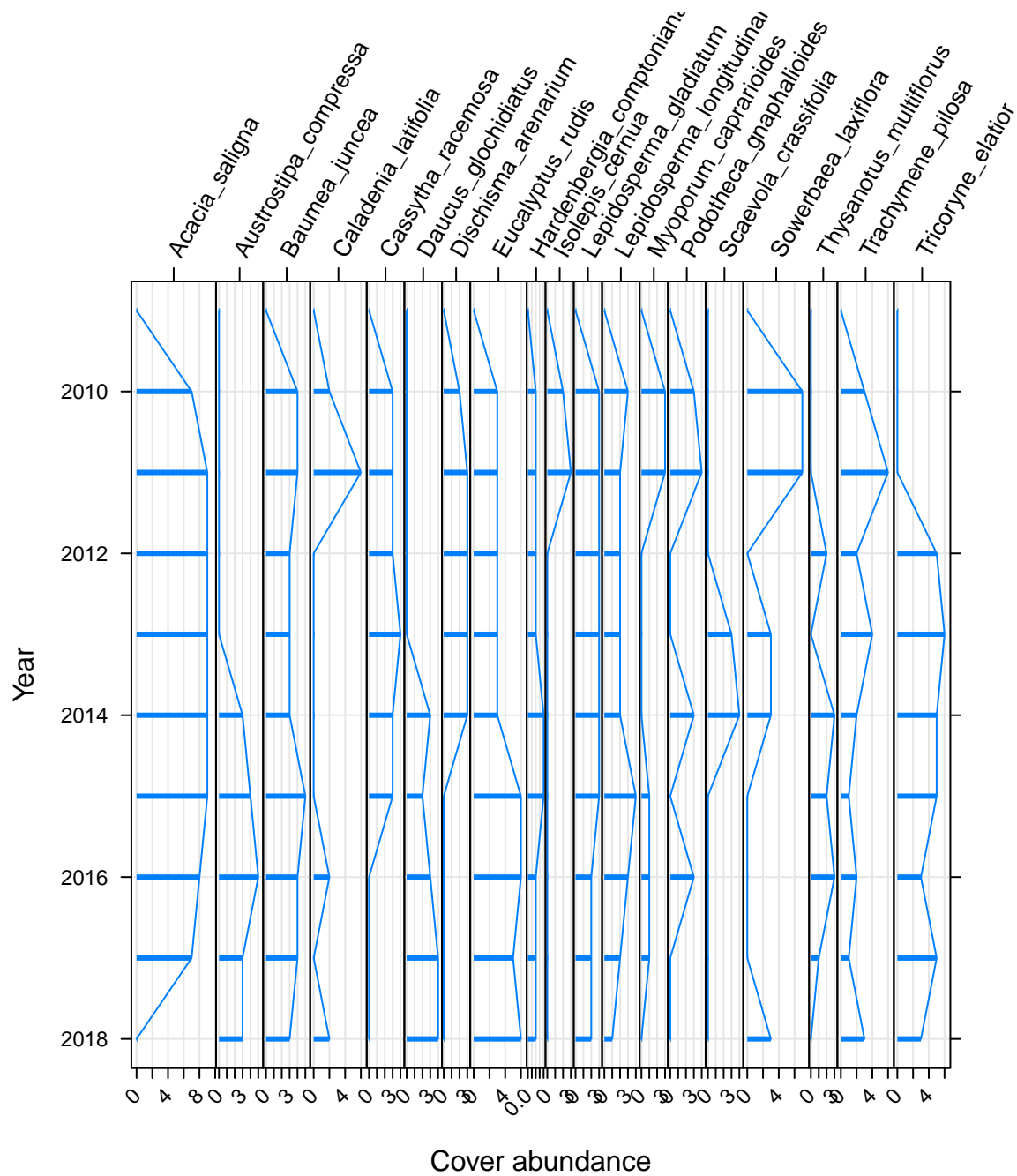
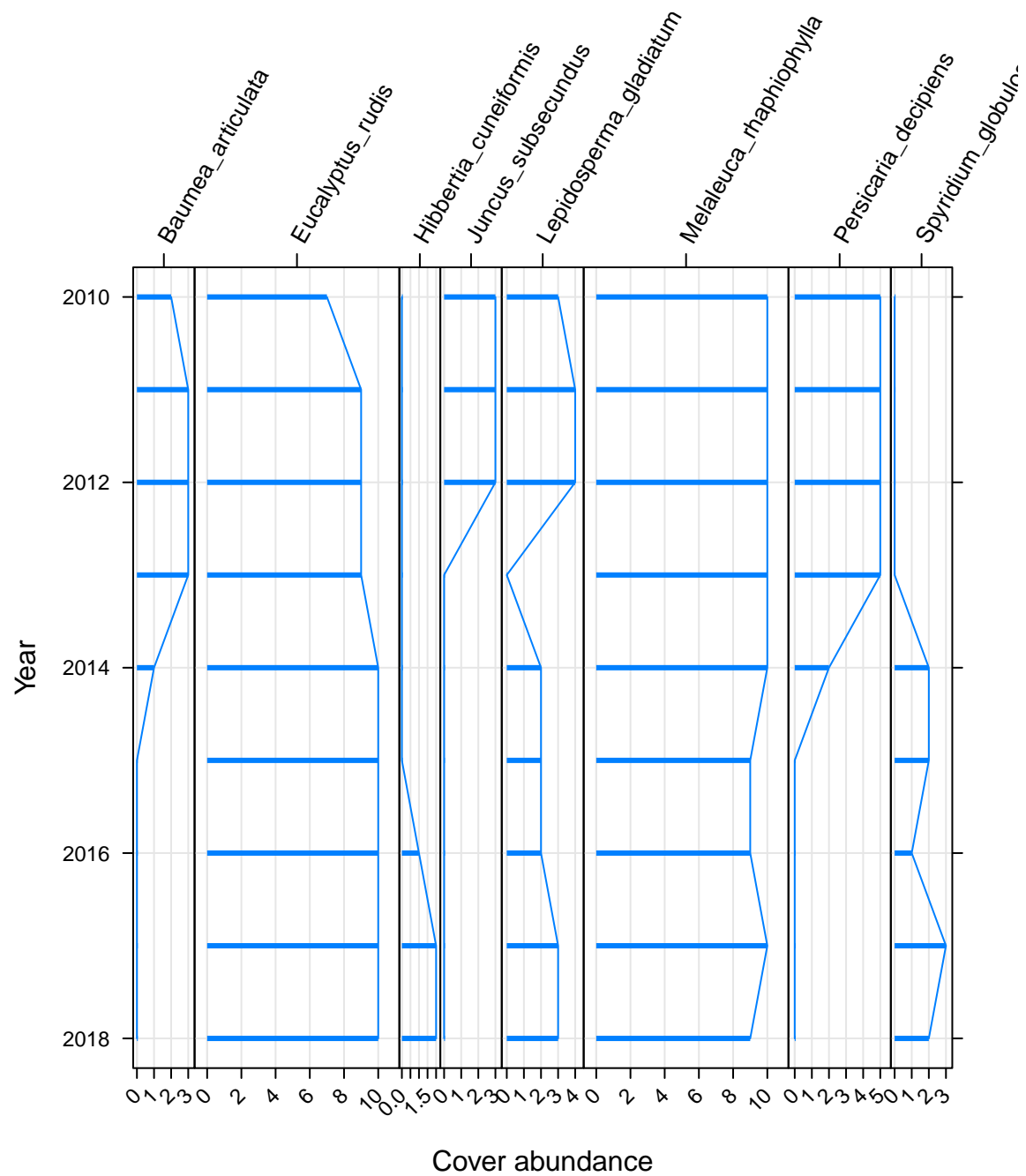


Figure 25: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Loch McNess









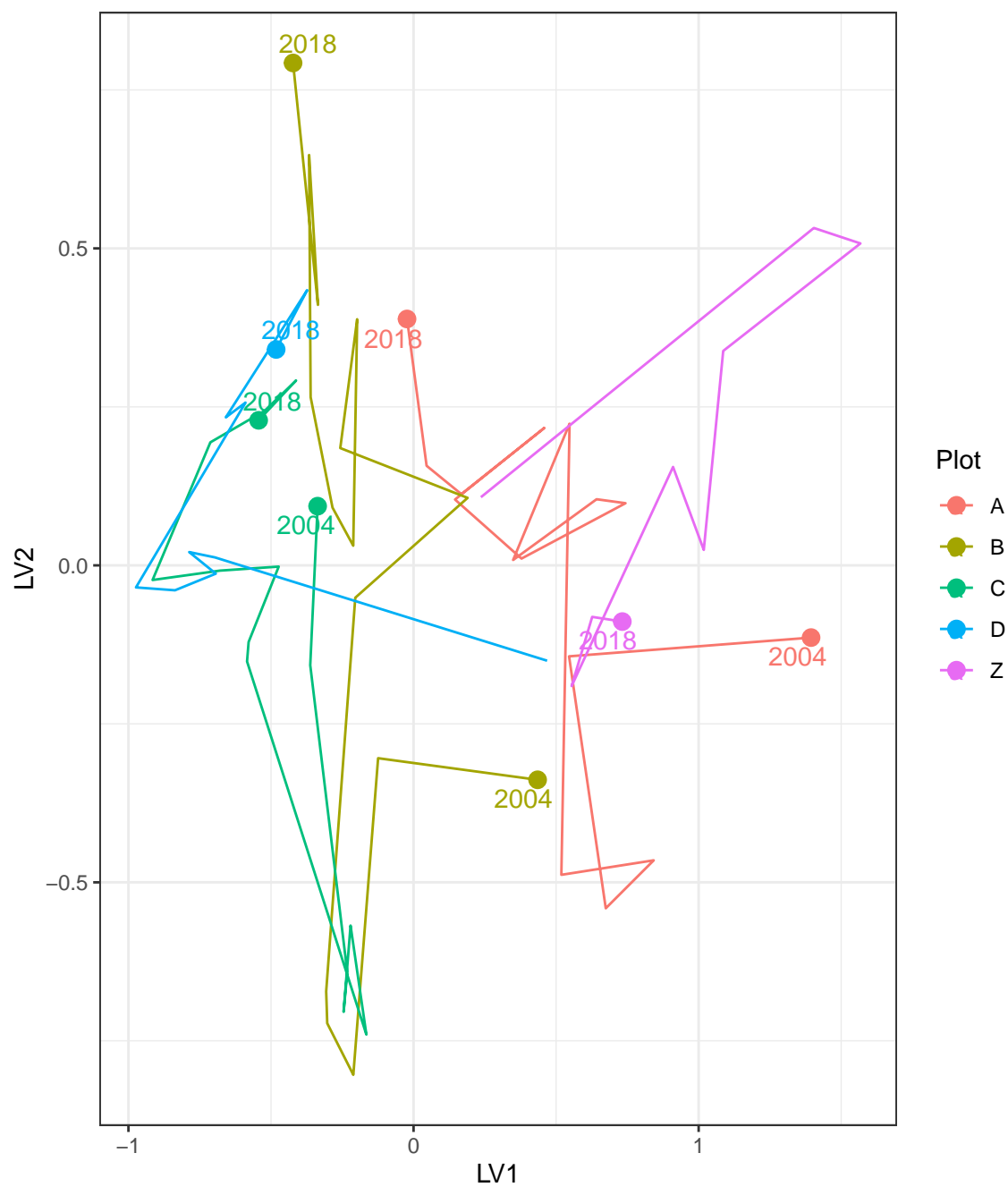


Figure 26: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

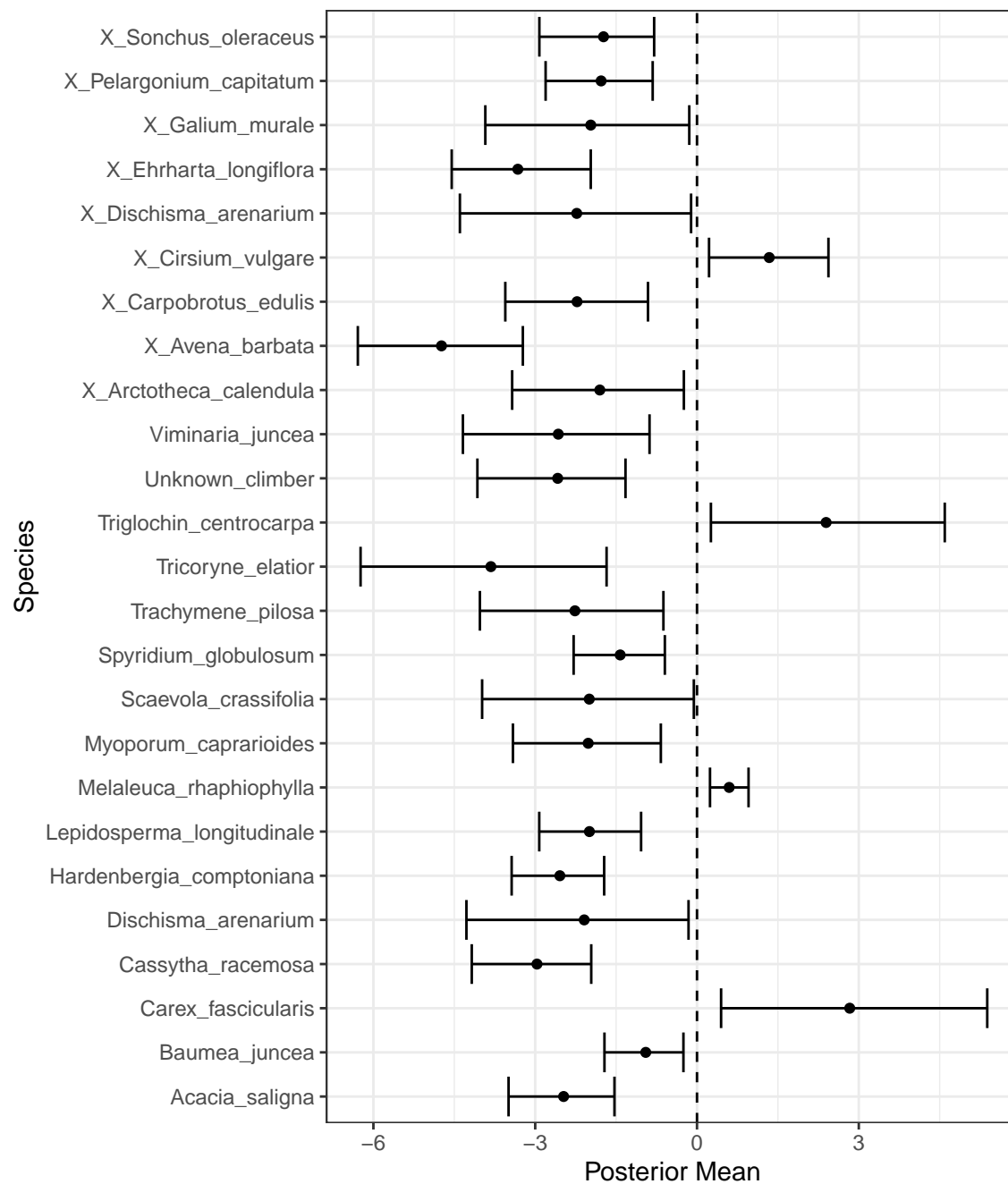
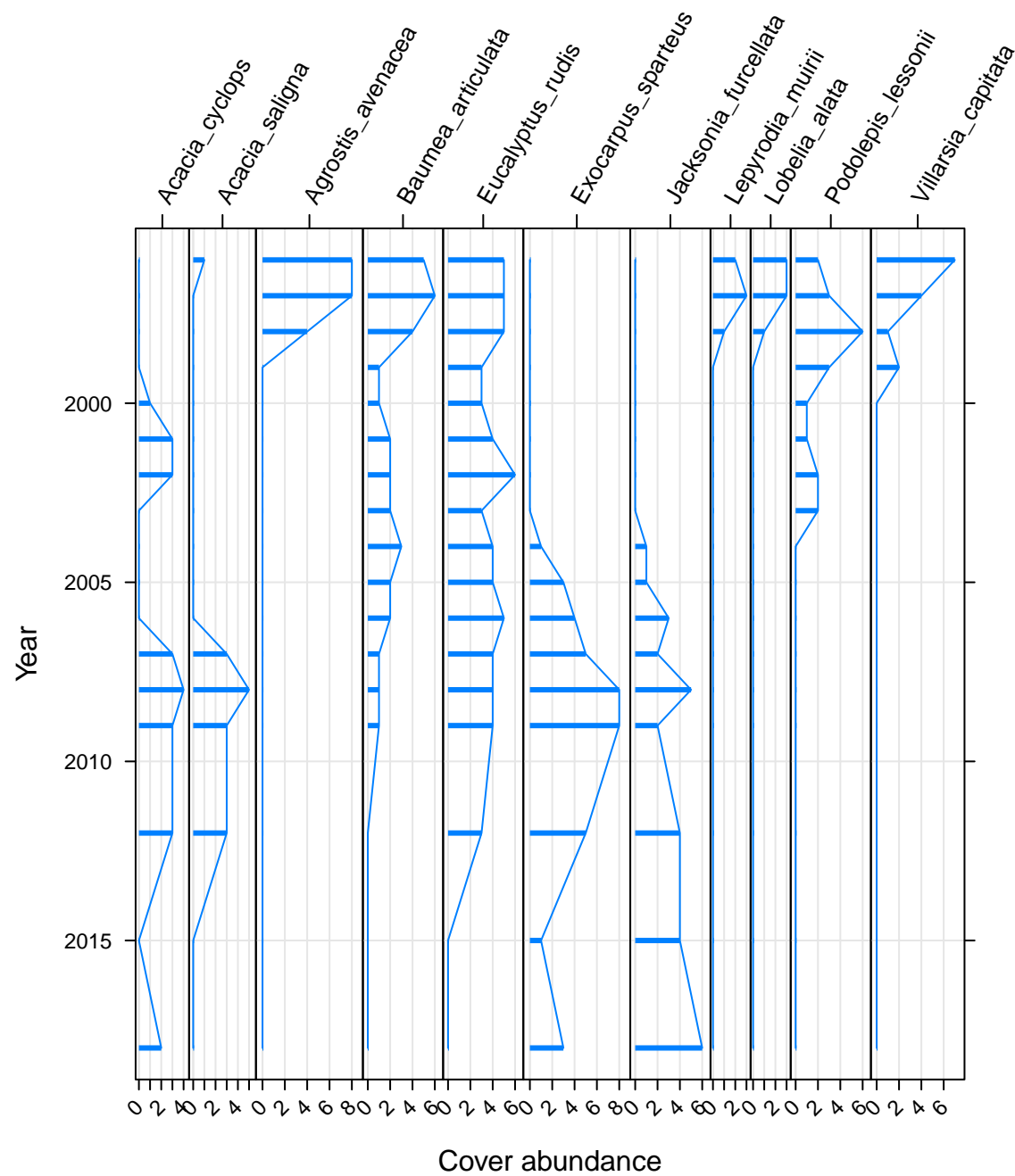


Figure 27: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

Mariginiup

Five year summaries of surface water level data at Mariginiup

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	41.997	41.190	0.807	September	February	175.600
08/1999 - 07/2004	41.791	41.286	0.505	October	July	135.600
08/2004 - 07/2009	41.484	41.274	0.210	September	July	111.600
08/2009 - 07/2014	41.254	41.066	0.188	October	January	21.400
08/2014 - 07/2019	41.395	41.000	0.395	September	January	133.800



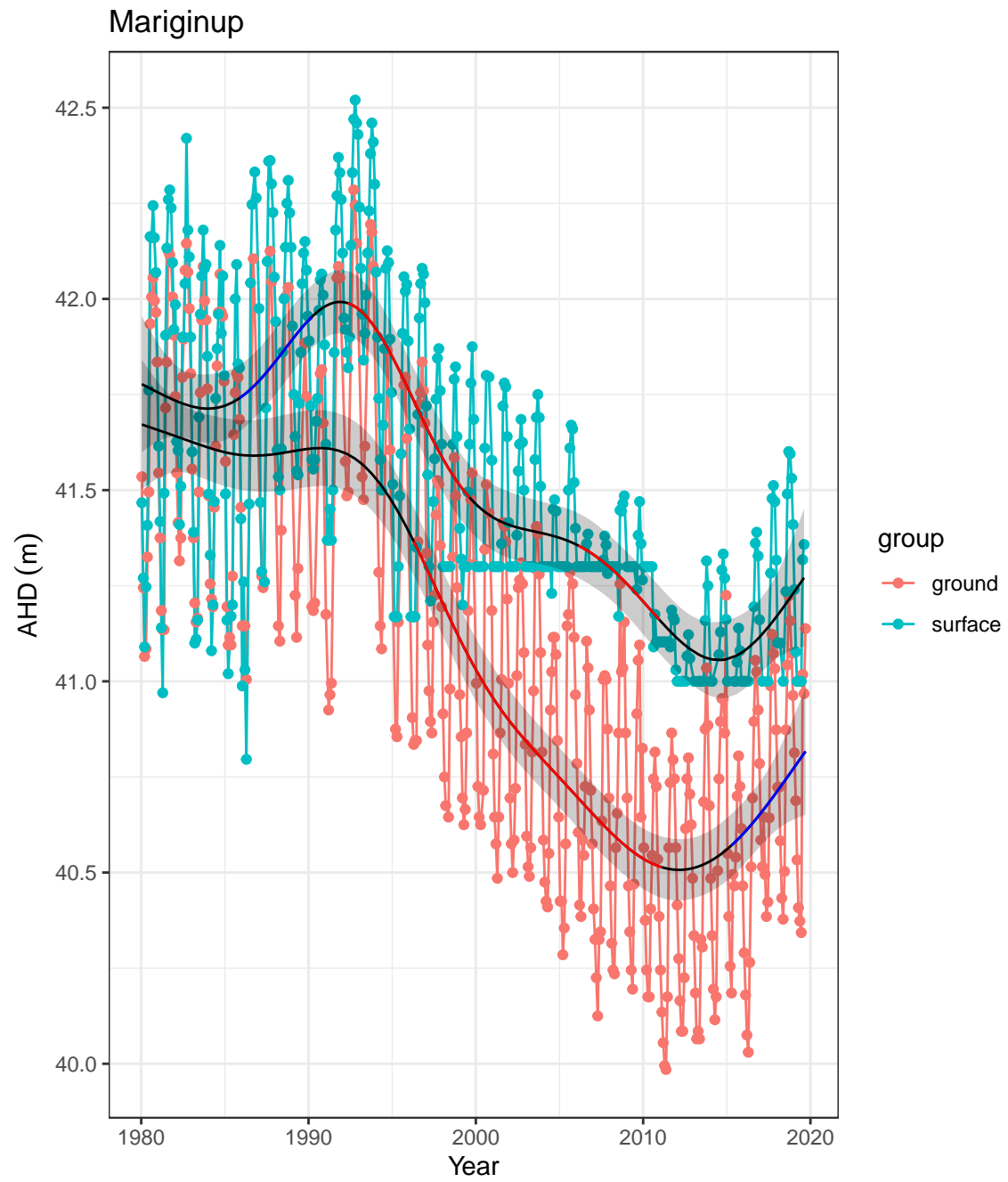
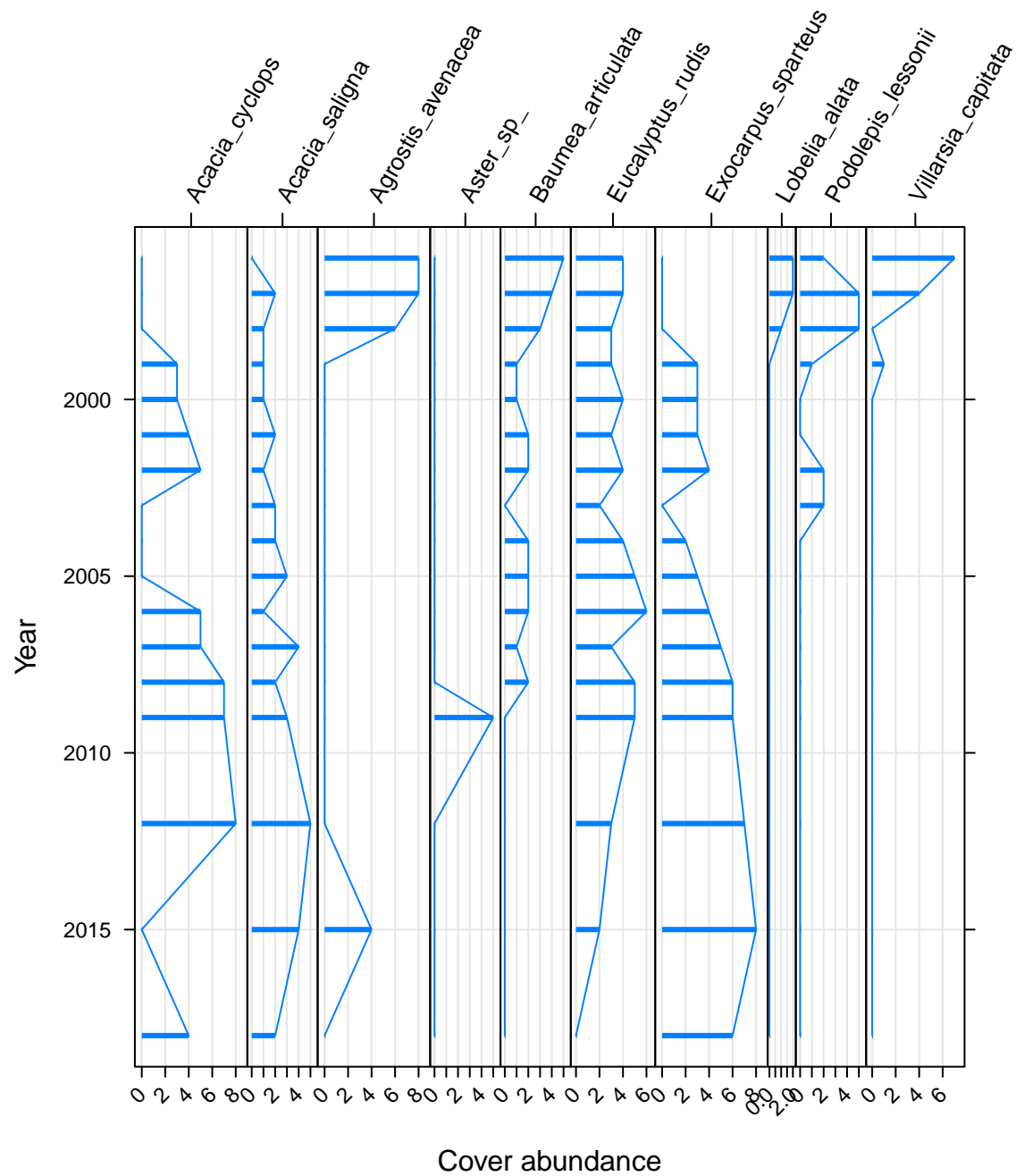
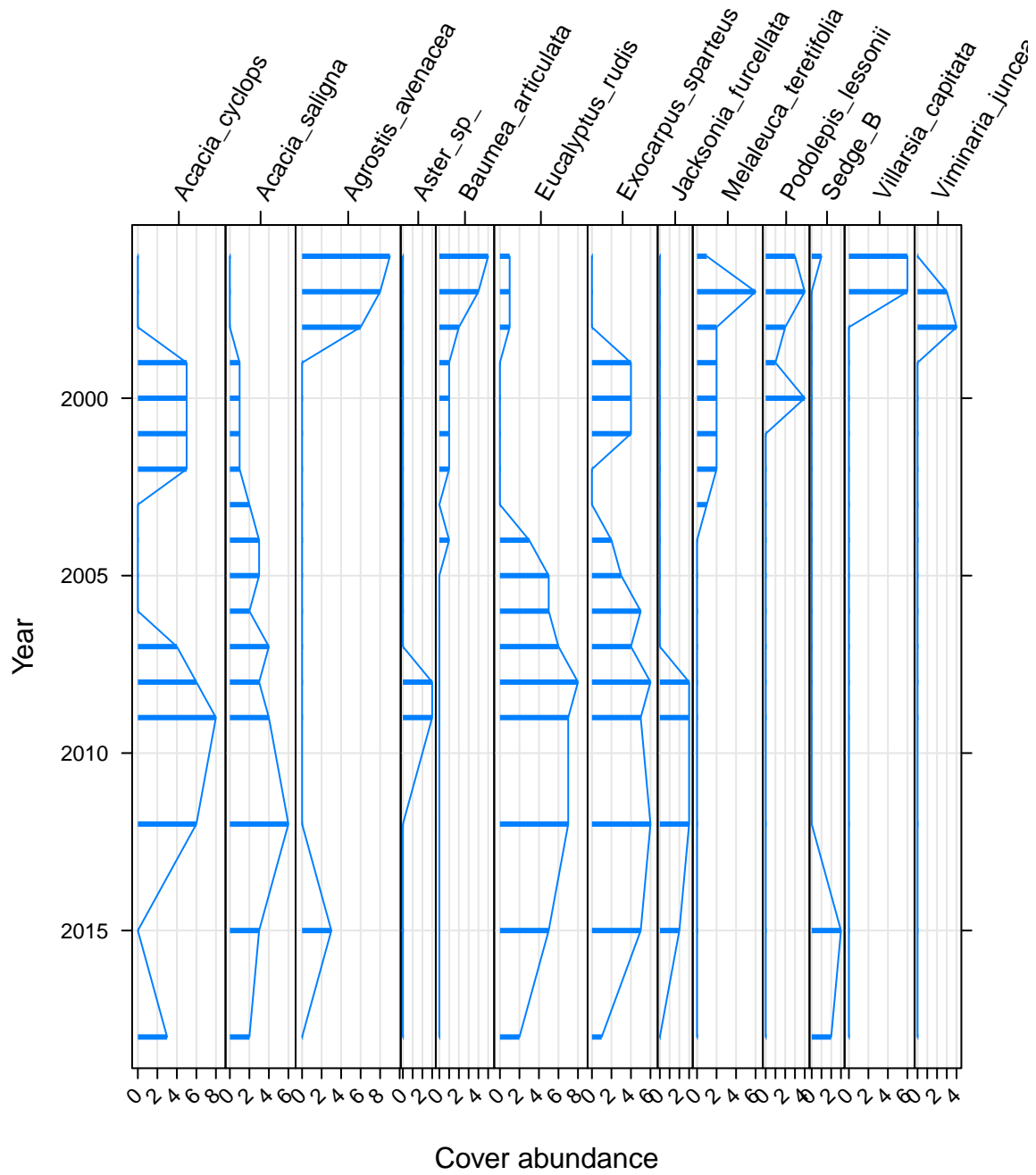


Figure 28: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Mariginup





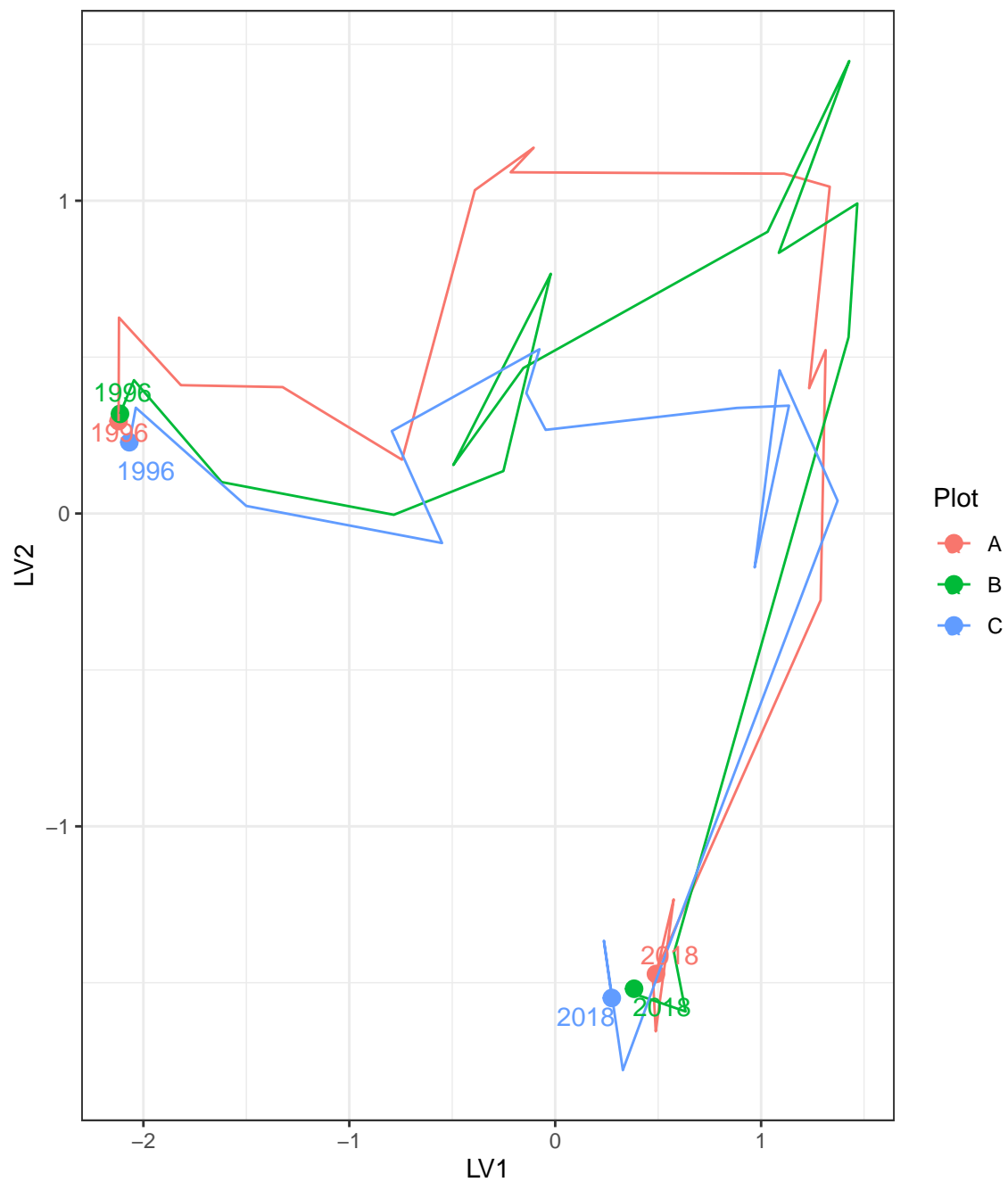


Figure 29: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

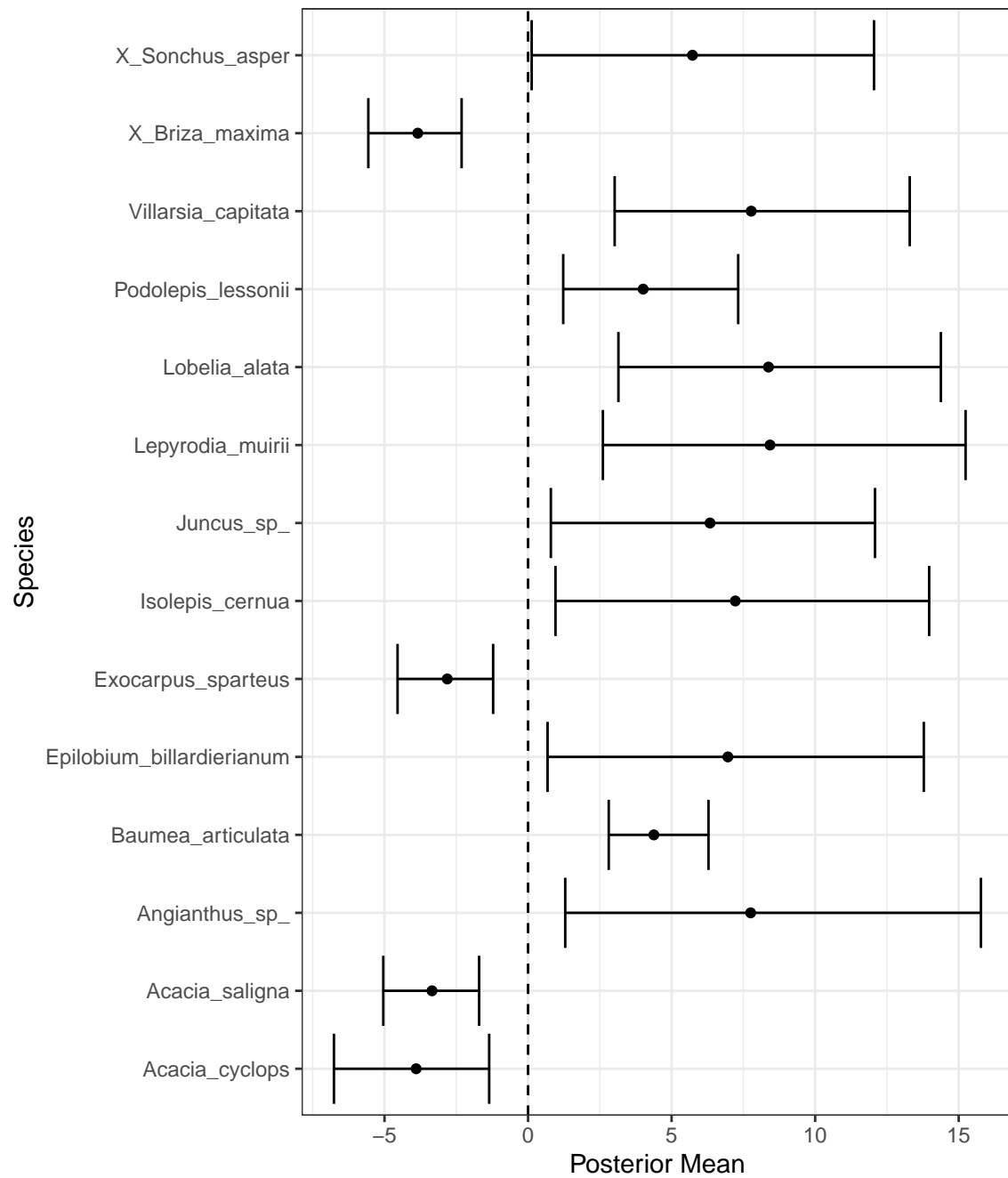


Figure 30: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

MM59B

Five year summaries of surface water level data at
MM59B

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	18.880	18.002	0.878	September	May	221.200
08/1999 - 07/2004	18.614	17.794	0.820	October	April	188.400
08/2004 - 07/2009	18.606	17.926	0.680	October	March	144.000
08/2009 - 07/2014	18.768	18.079	0.689	October	May	205.600
08/2014 - 07/2019	19.036	18.439	0.597	September	April	223.800

Nowergup

Five year summaries of surface water level data at
Nowergup

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	17.005	16.166	0.839	October	May	114.800
08/1999 - 07/2004	16.687	15.964	0.723	October	May	20.400
08/2004 - 07/2009	16.777	16.216	0.561	October	September	-1.400
08/2009 - 07/2014	16.161	15.988	0.173	September	December	78.800
08/2014 - 07/2019	16.000	15.615	0.385	September	November	56.400

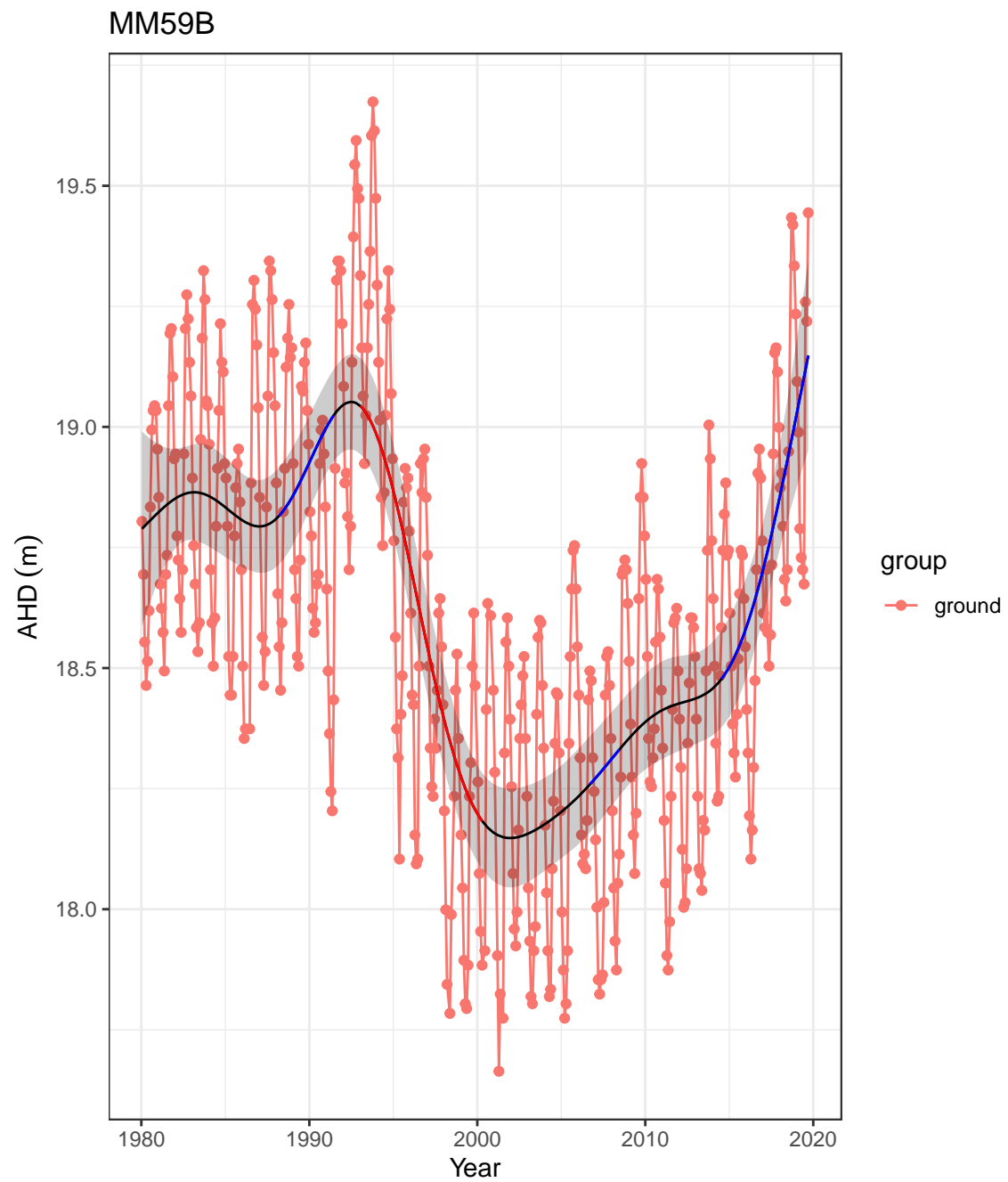


Figure 31: Ground and surface water levels recorded at bores and staff gauges in the vicinity of MM59B

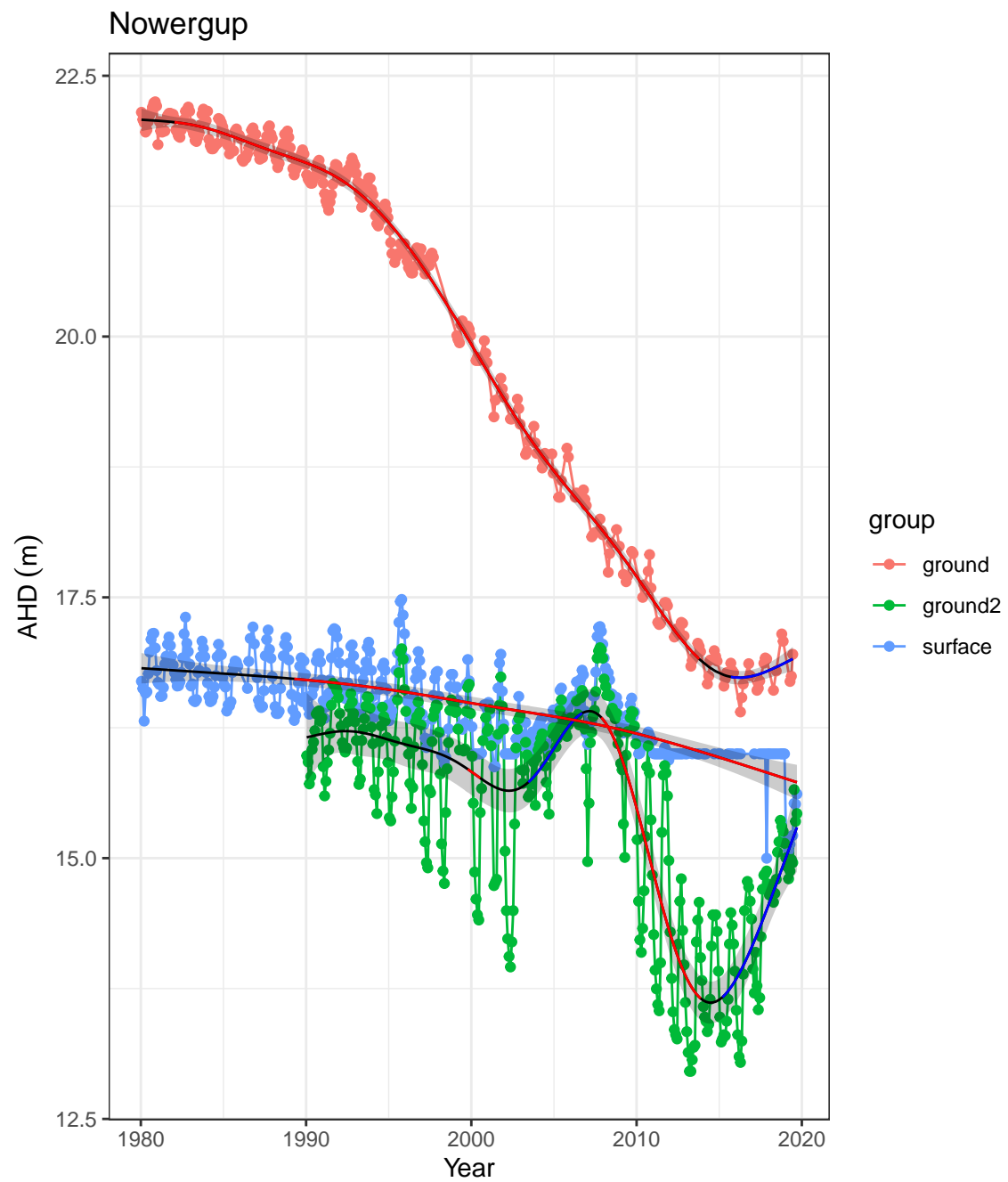
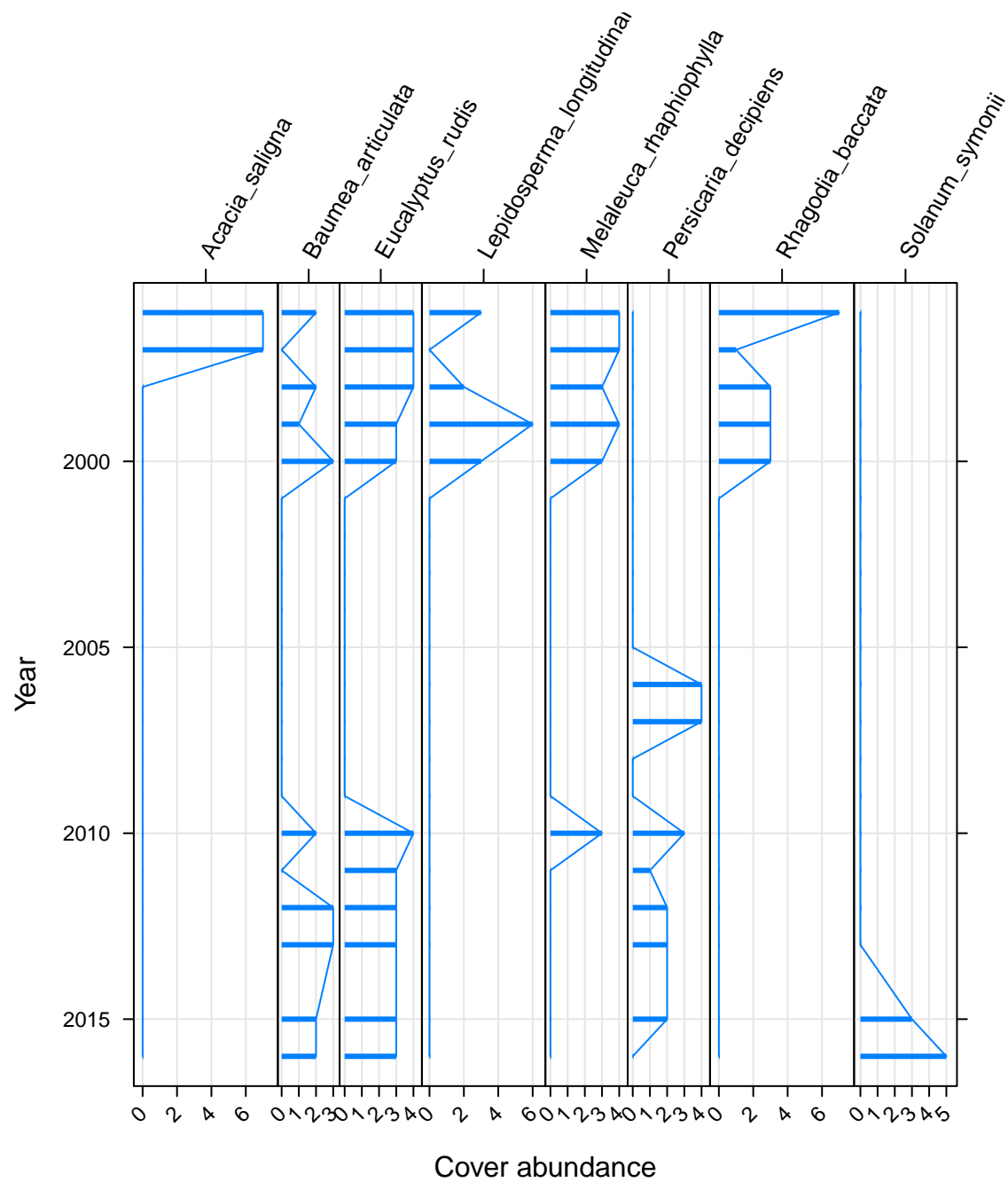
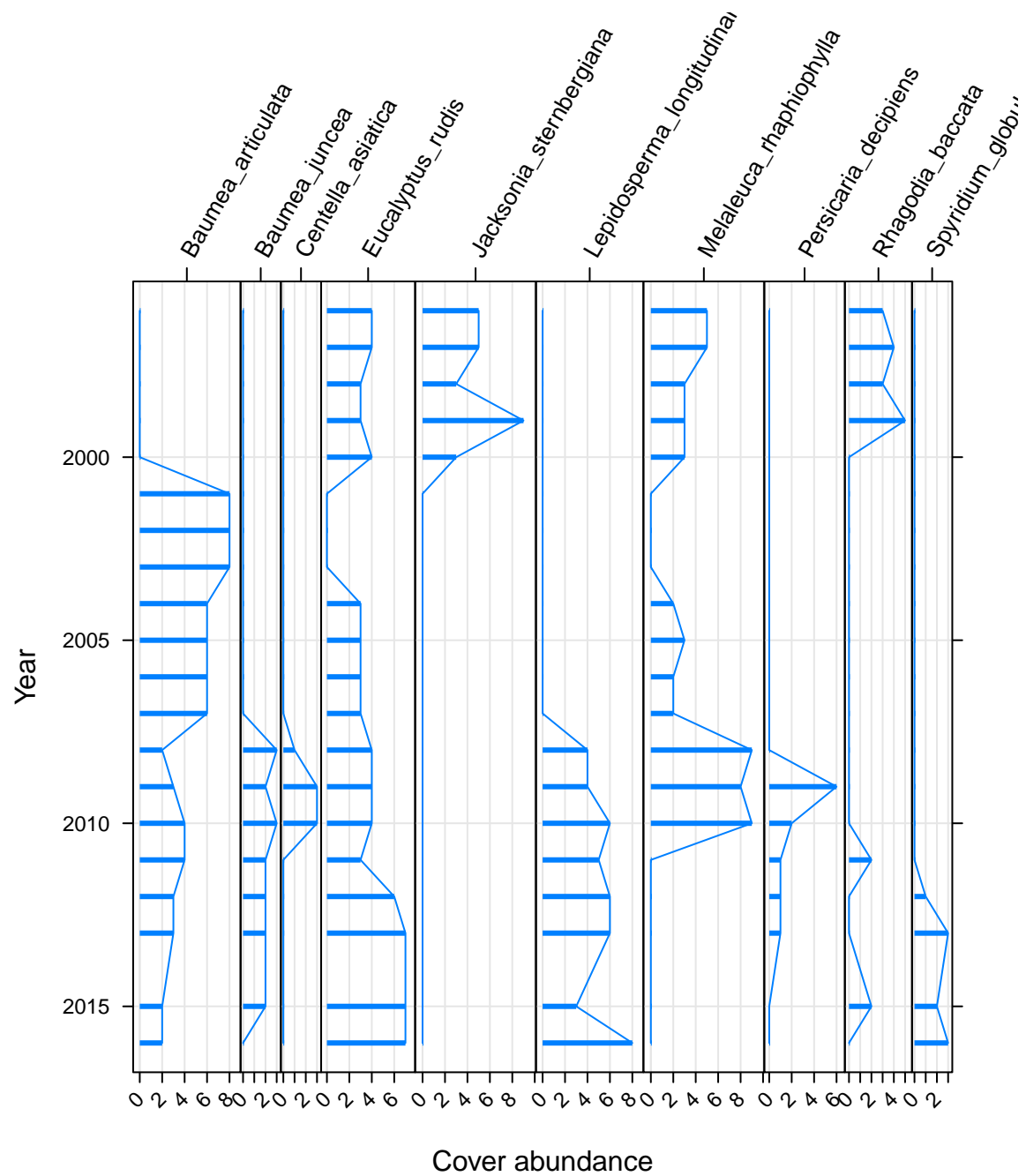
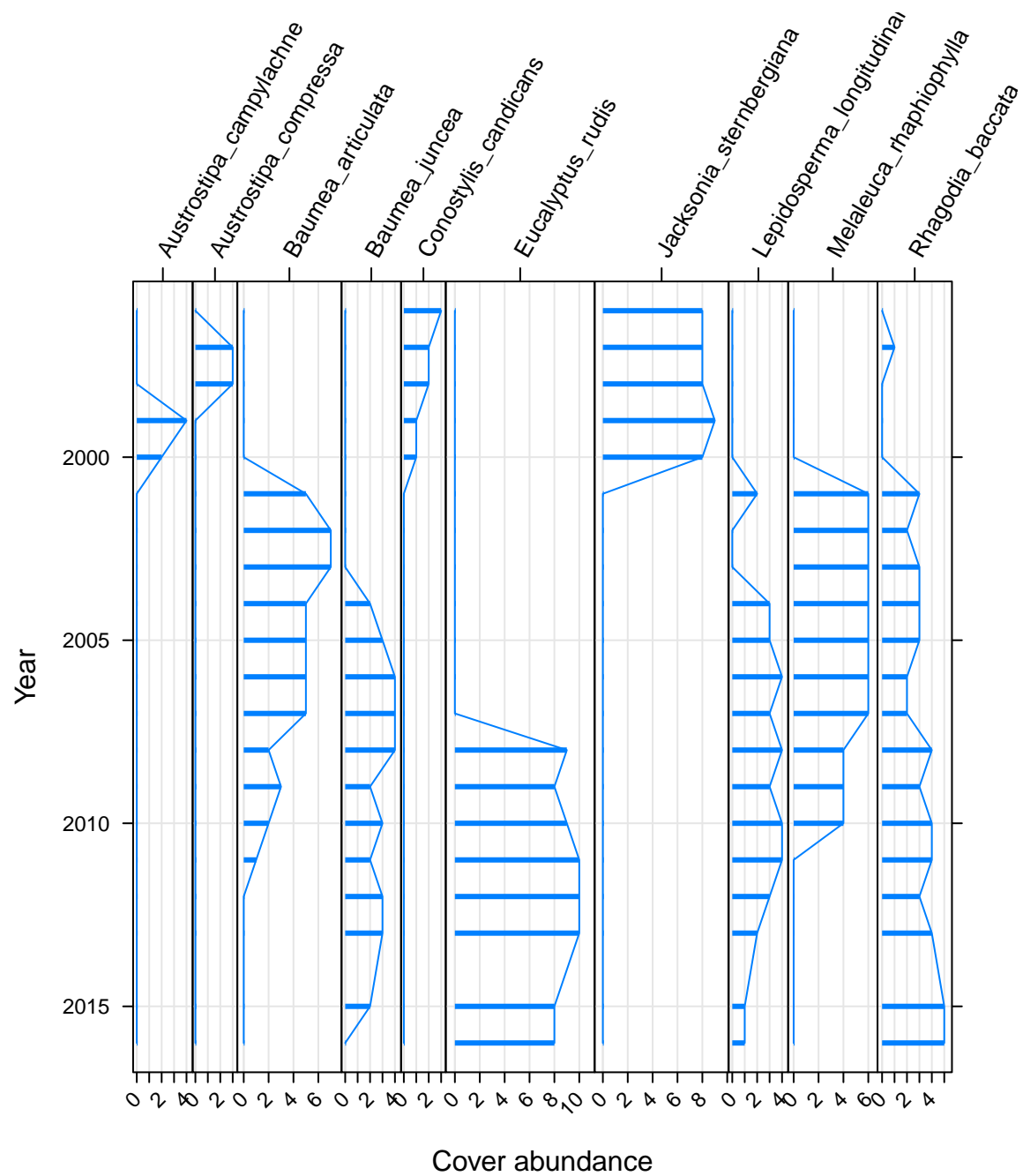
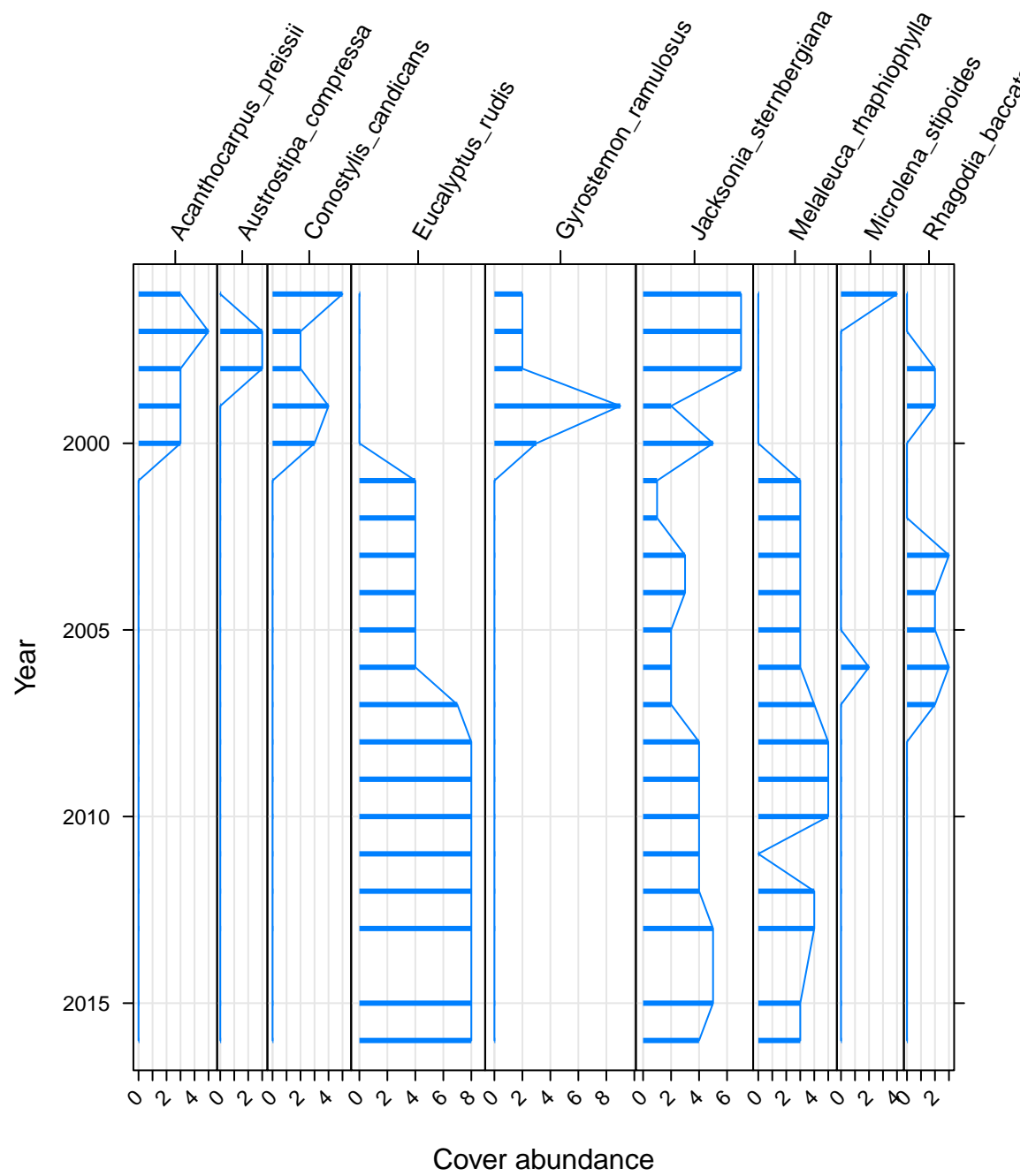


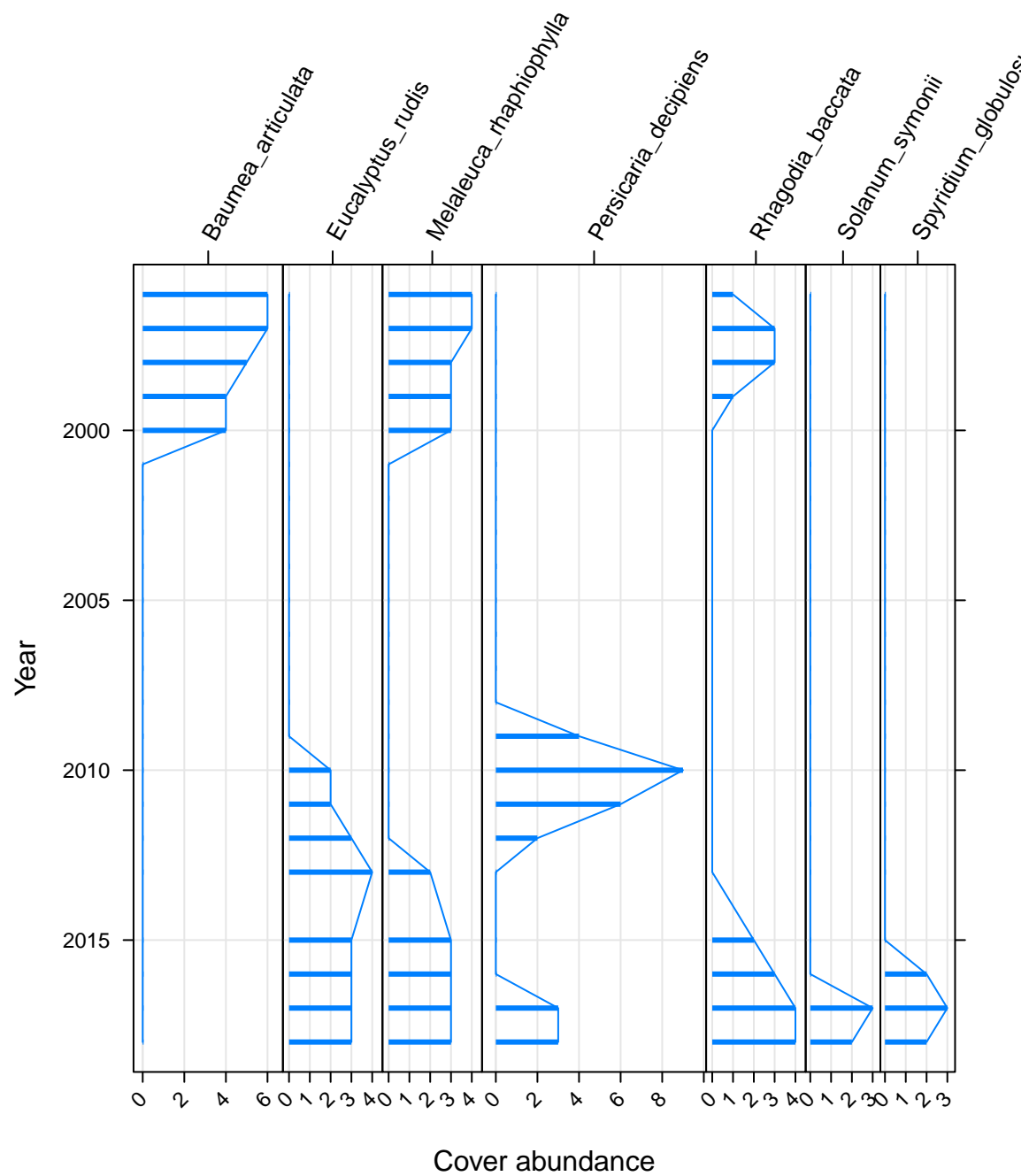
Figure 32: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Nowergup

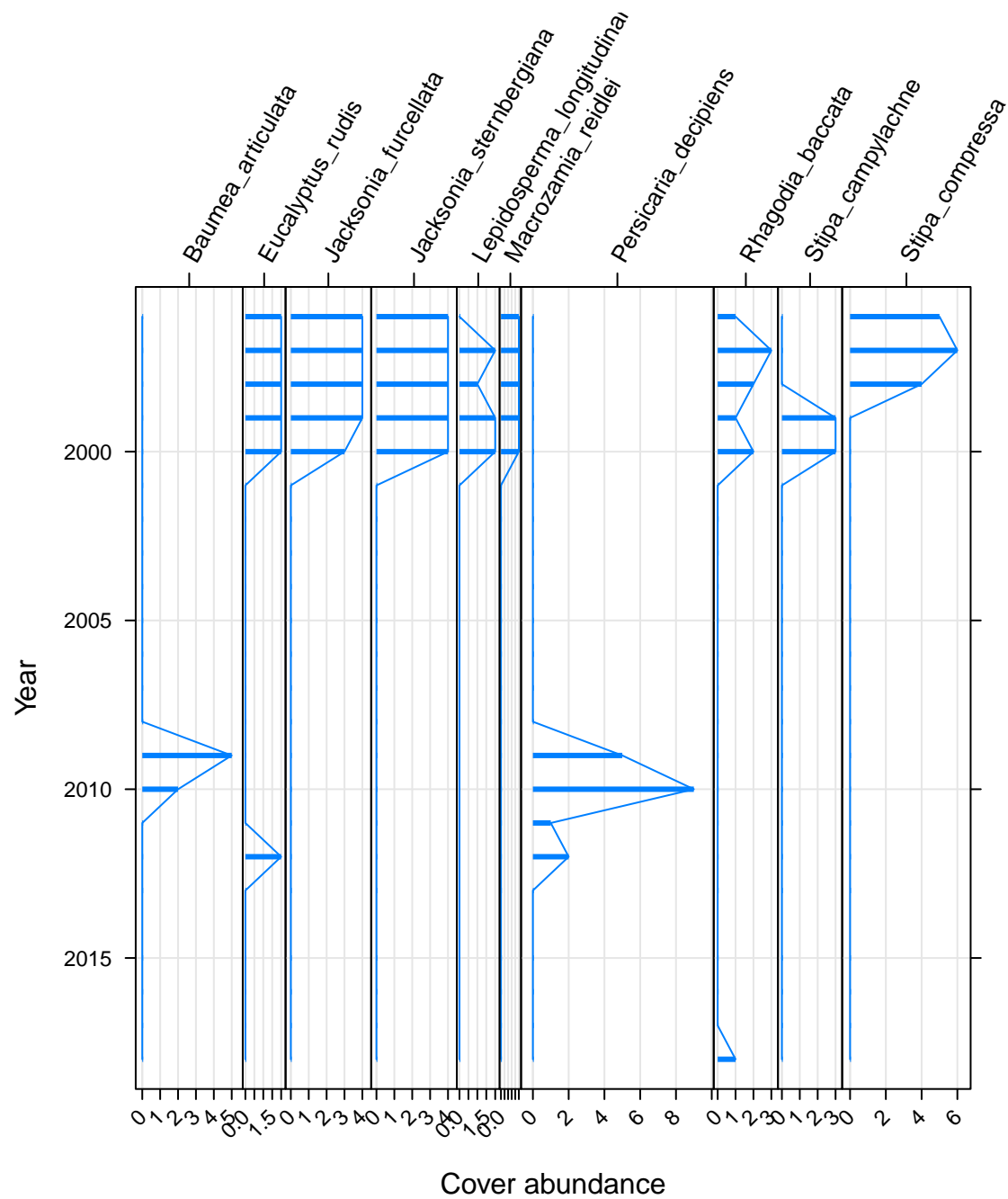


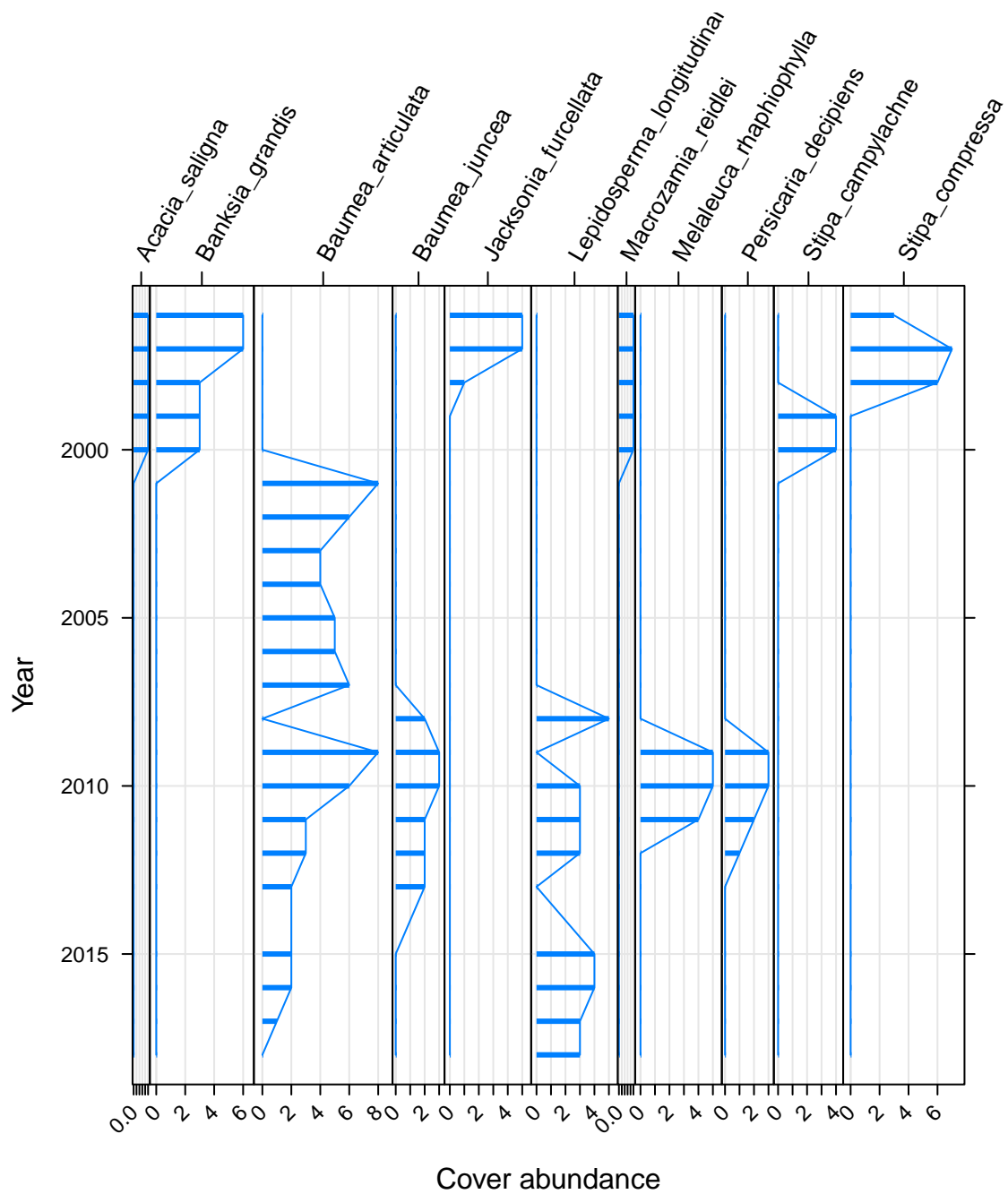


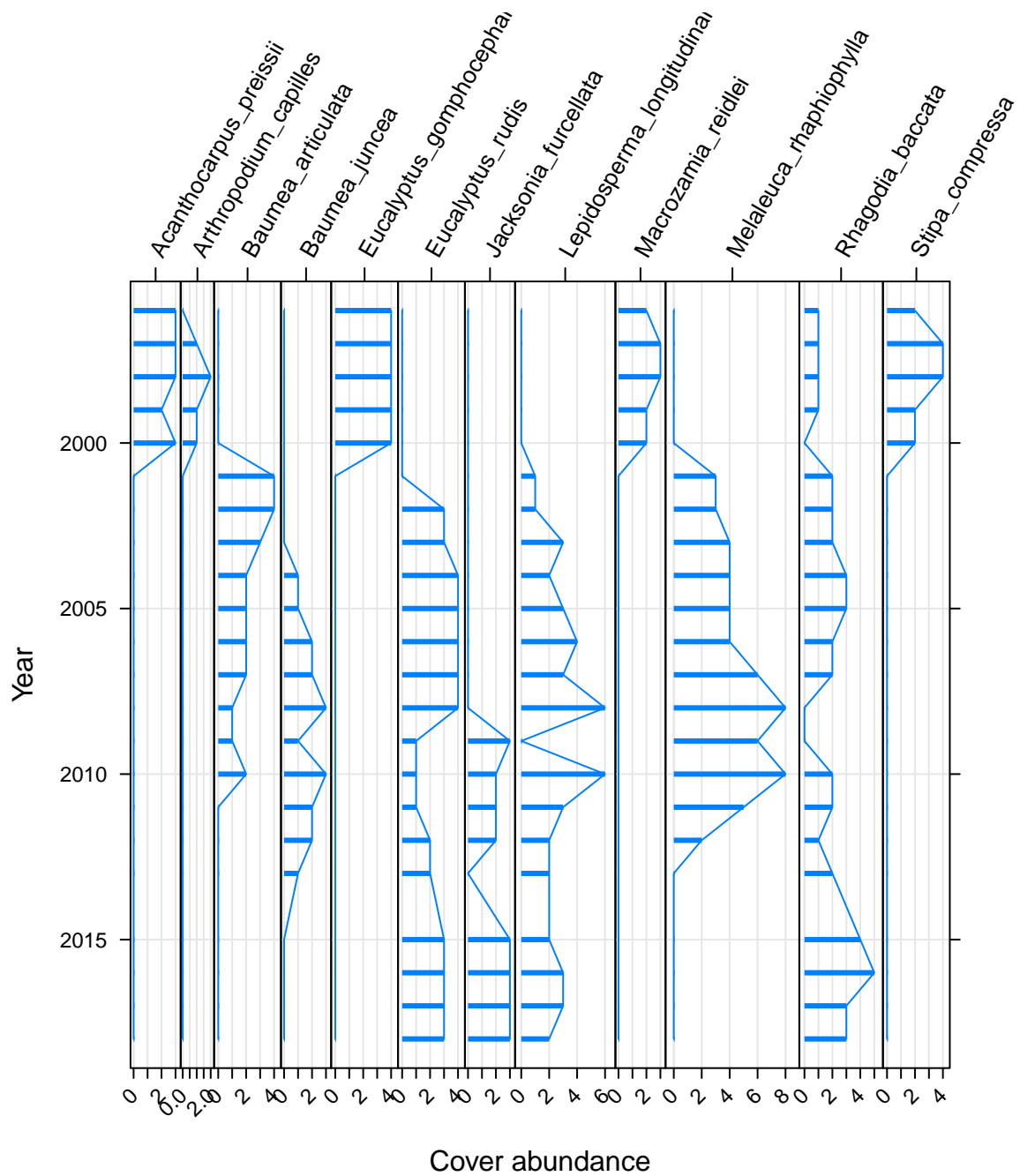












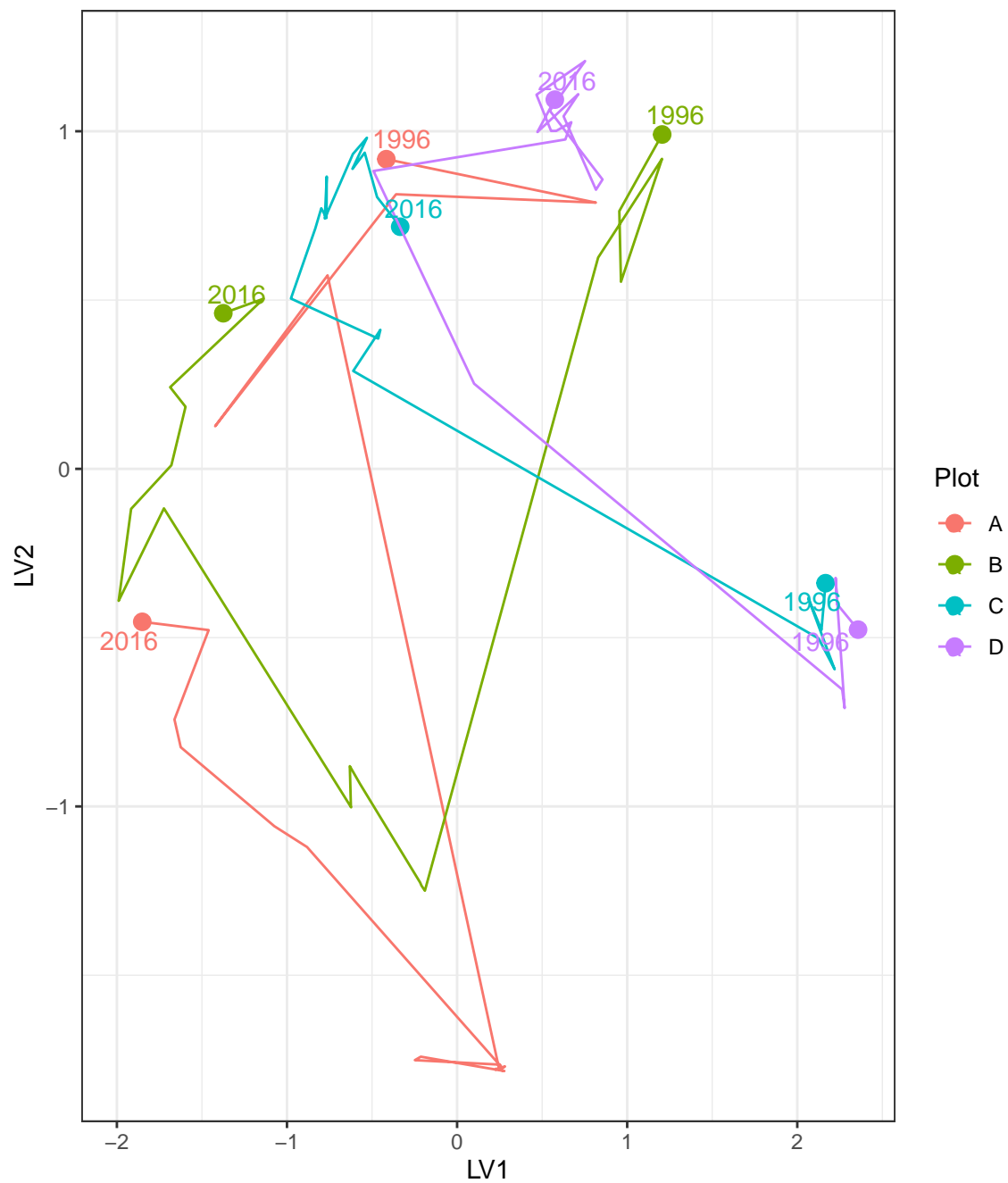


Figure 33: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

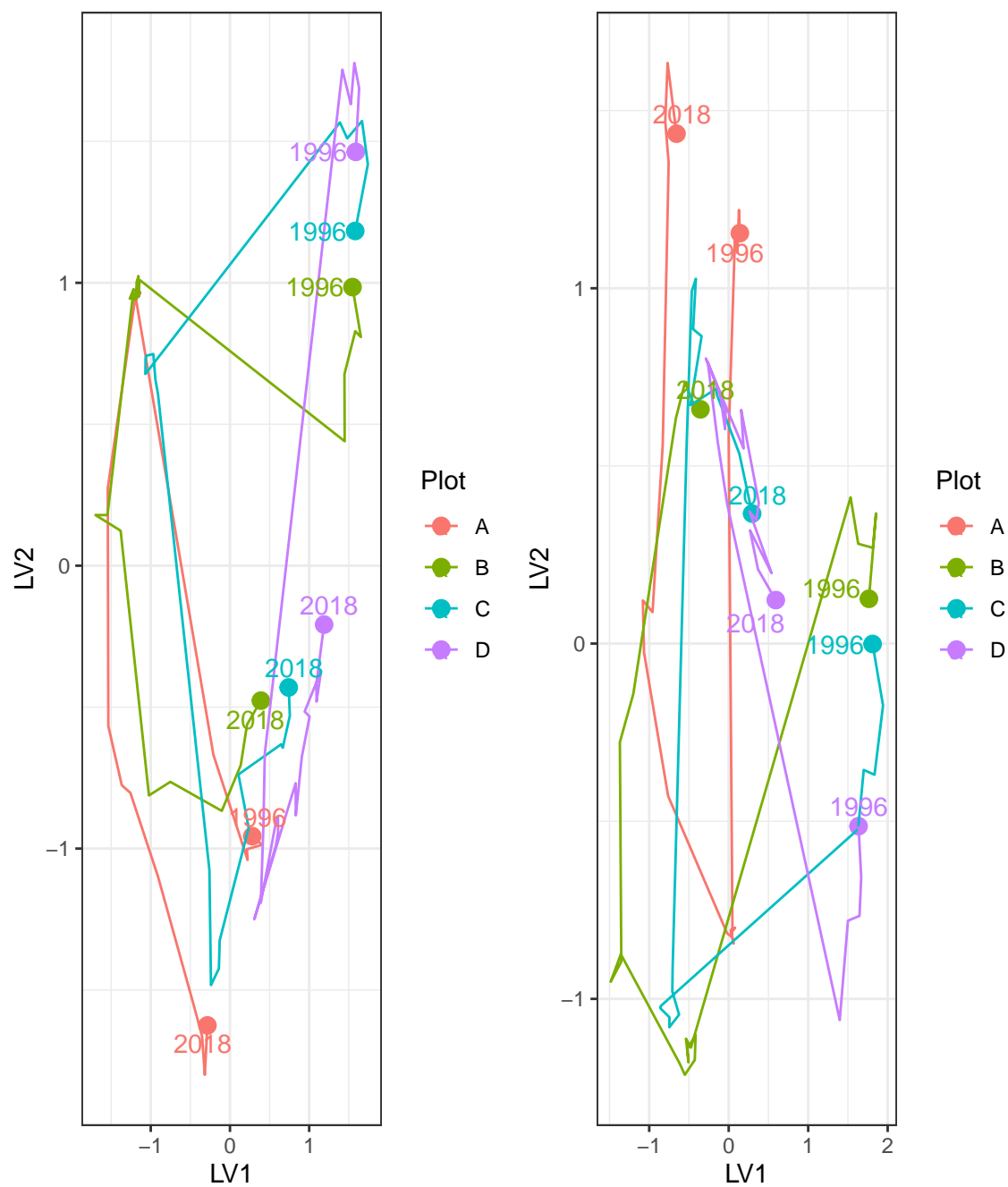


Figure 34: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

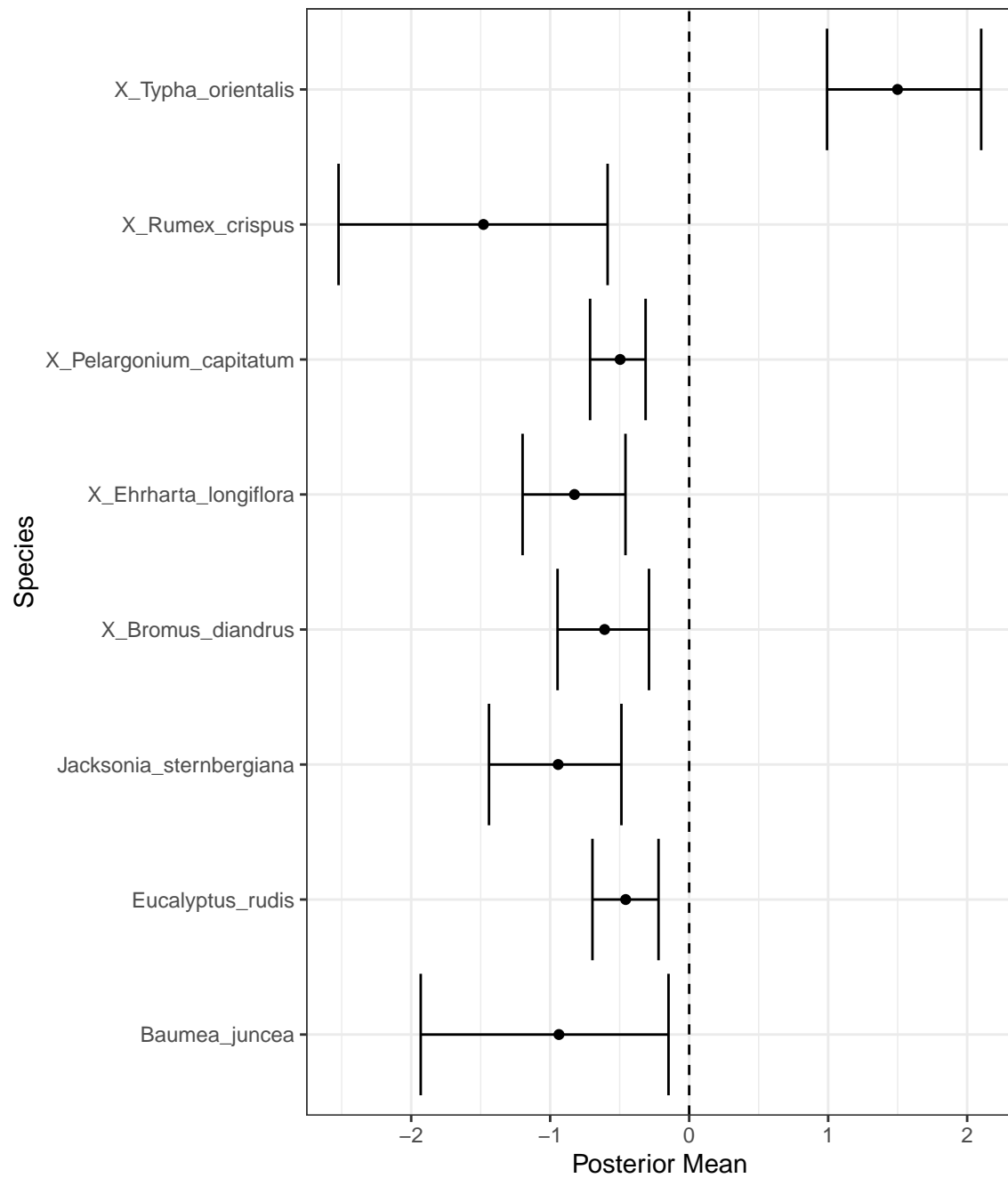


Figure 35: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

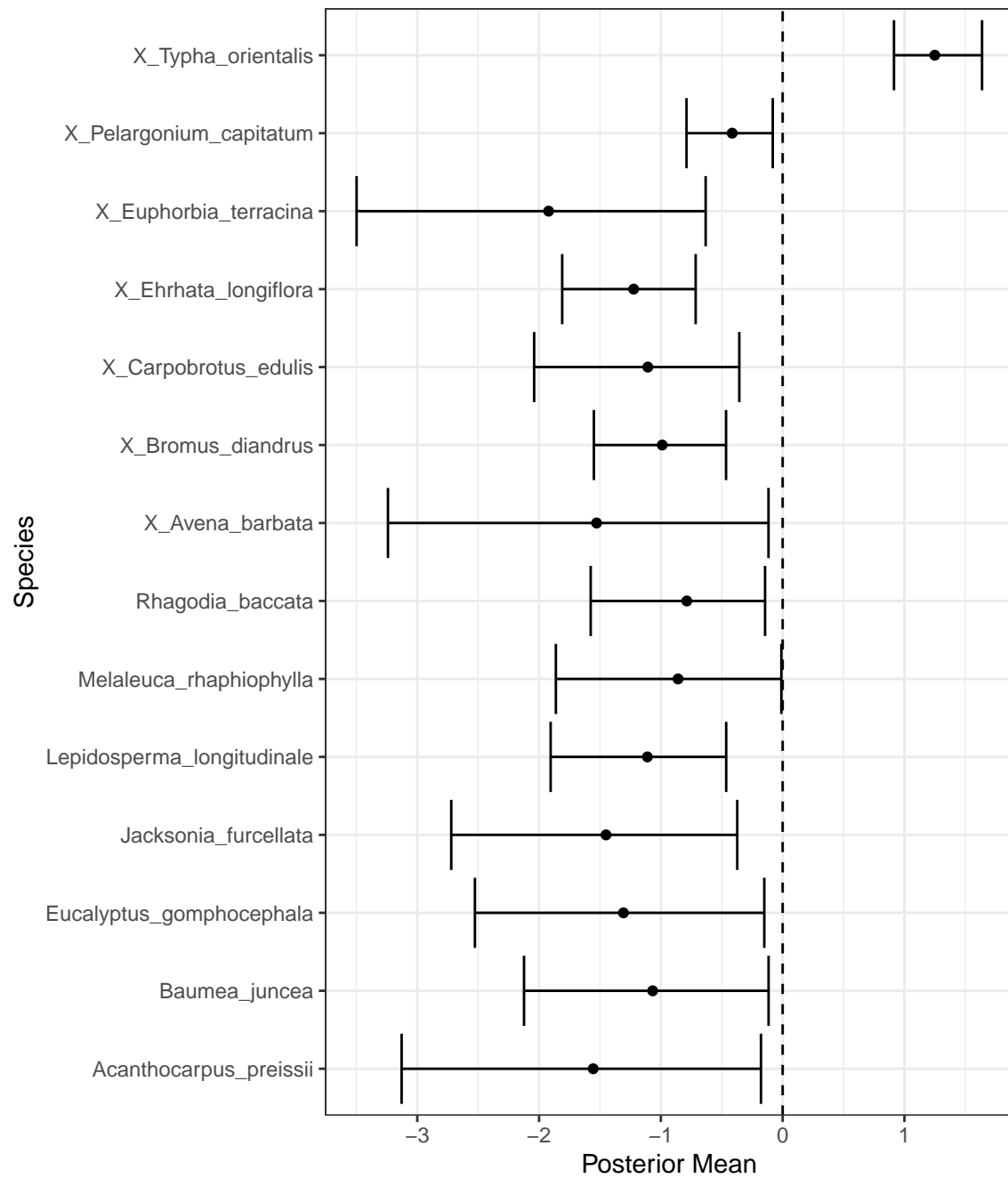


Figure 36: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

Pipidinny

Five year summaries of surface water level data at Pipidinny						
Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	3.169	1.831	1.337	September	May	212.600
08/1999 - 07/2004	2.770	1.794	0.976	October	March	167.800
08/2004 - 07/2009	2.386	1.996	0.390	September	November	11.800
08/2009 - 07/2014	1.981	1.000	0.981	October	July	87.800
08/2014 - 07/2019	1.967	1.000	0.967	September	January	124.400

PM9

Five year summaries of surface water level data at PM9						
Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	58.436	57.708	0.728	November	June	251.600
08/1999 - 07/2004	57.500	56.822	0.678	September	July	201.200
08/2004 - 07/2009	56.516	56.022	0.494	October	July	256.800
08/2009 - 07/2014	55.179	54.738	0.441	November	September	206.600
08/2014 - 07/2019	54.385	52.830	1.555	December	May	242.500

Quin Brook

Five year summaries of surface water level data at Quin Brook						
Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	59.032	58.774	0.258	January	July	125.200
08/1999 - 07/2004	58.224	58.064	0.160	January	April	93.400
08/2004 - 07/2009	57.109	56.864	0.245	October	April	203.200
08/2009 - 07/2014	55.572	55.430	0.142	November	April	196.000
08/2014 - 07/2019	54.122	54.013	0.109	October	October	47.200

Wilgarup

Five year summaries of surface water level data at Wilgarup						
Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	5.220	4.310	0.910	October	March	184.500
08/1999 - 07/2004	4.745	4.017	0.728	October	April	193.400
08/2004 - 07/2009	4.327	3.705	0.622	September	May	150.000
08/2009 - 07/2014	3.816	3.222	0.594	October	April	190.400
08/2014 - 07/2019	3.632	3.085	0.547	October	May	212.400

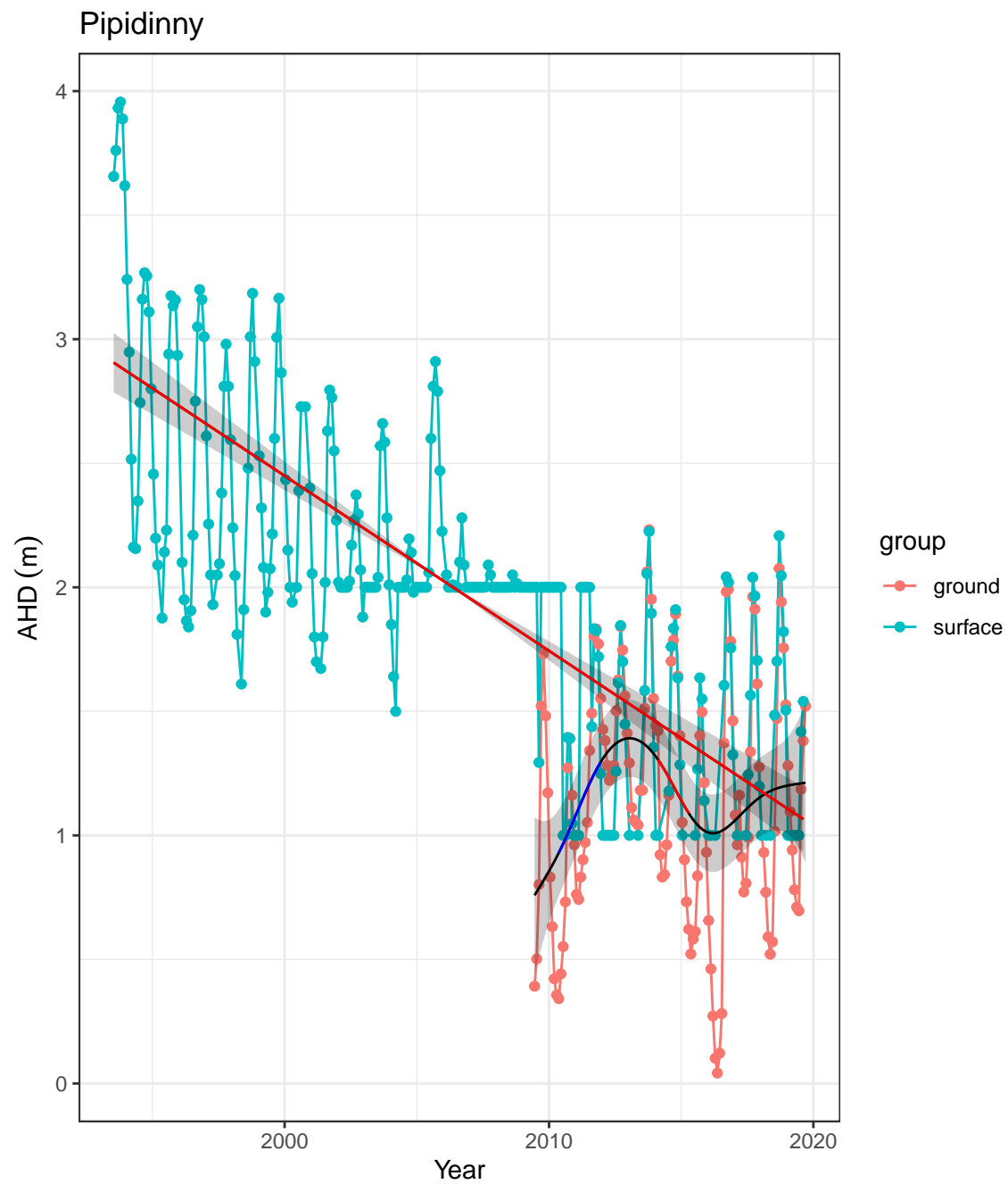


Figure 37: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Pipidinny

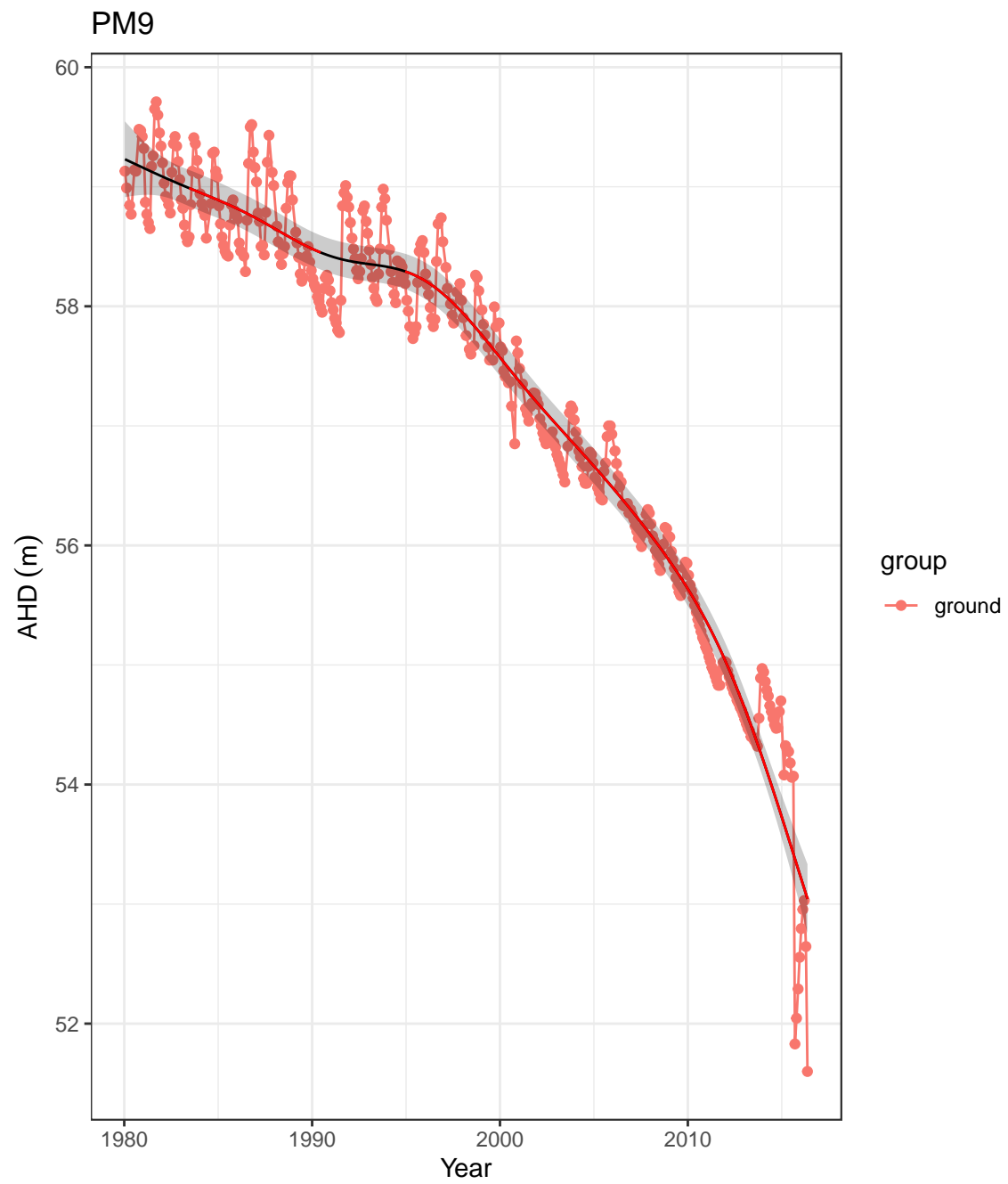


Figure 38: Ground and surface water levels recorded at bores and staff gauges in the vicinity of PM9

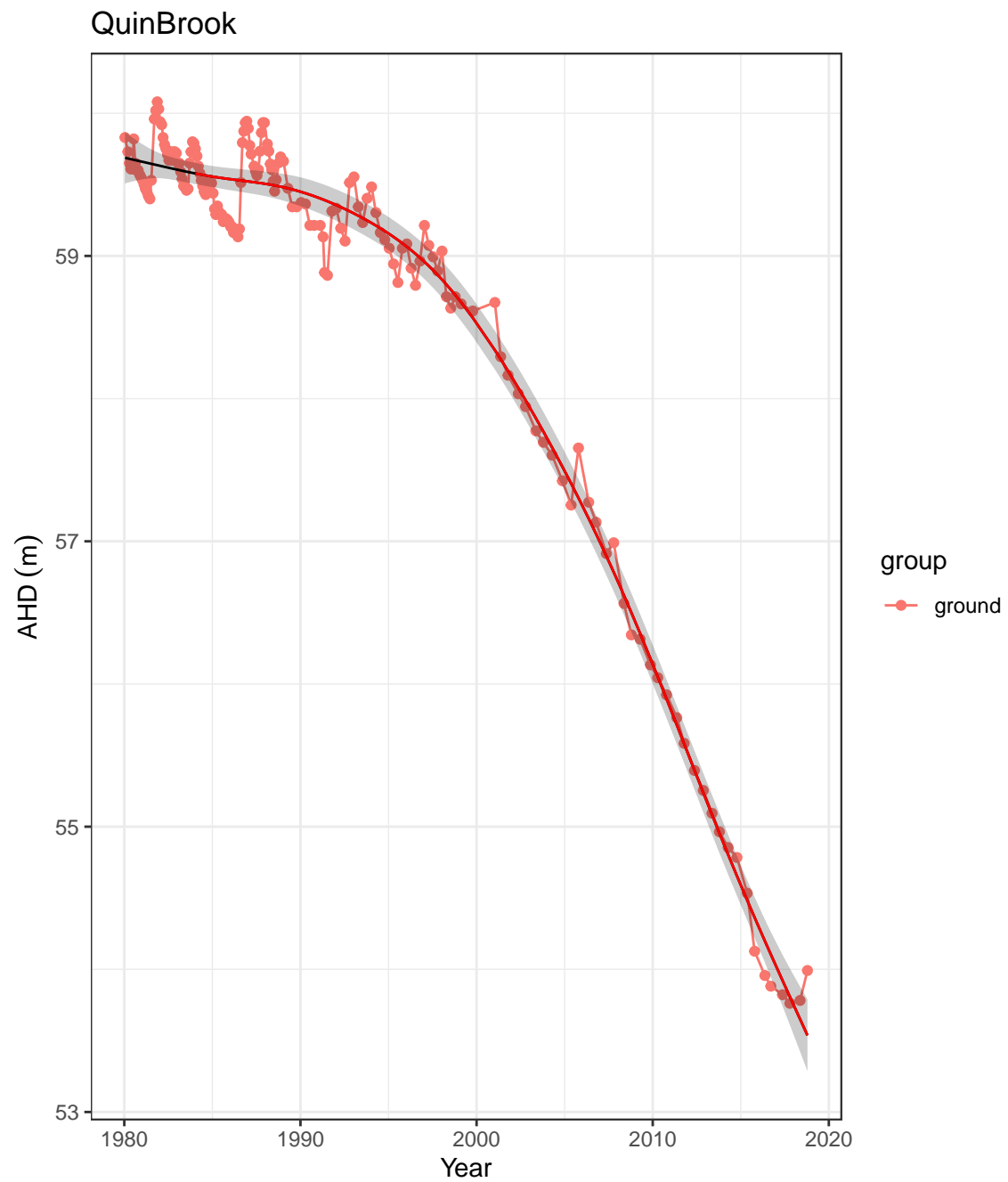


Figure 39: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Quin Brook

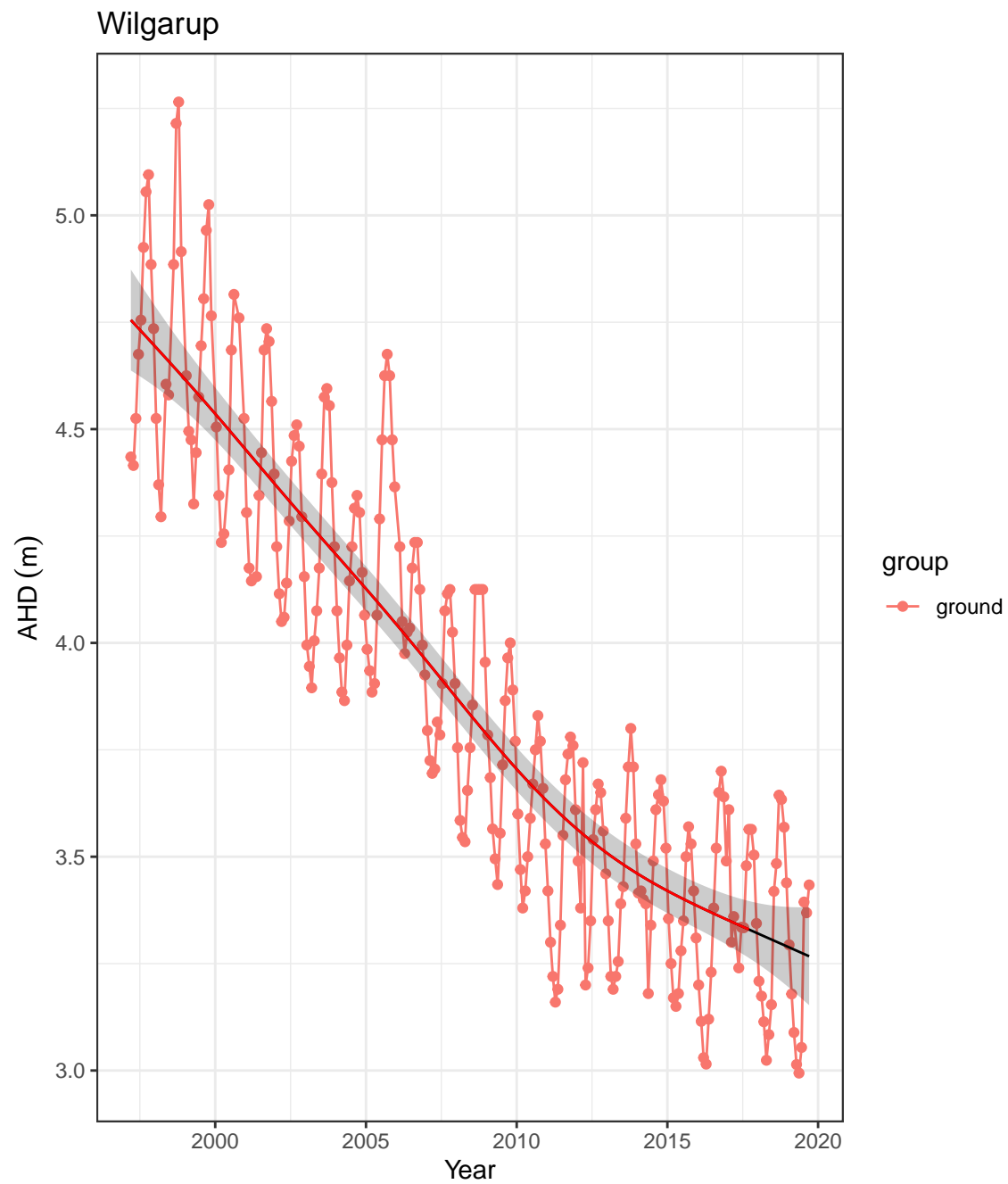
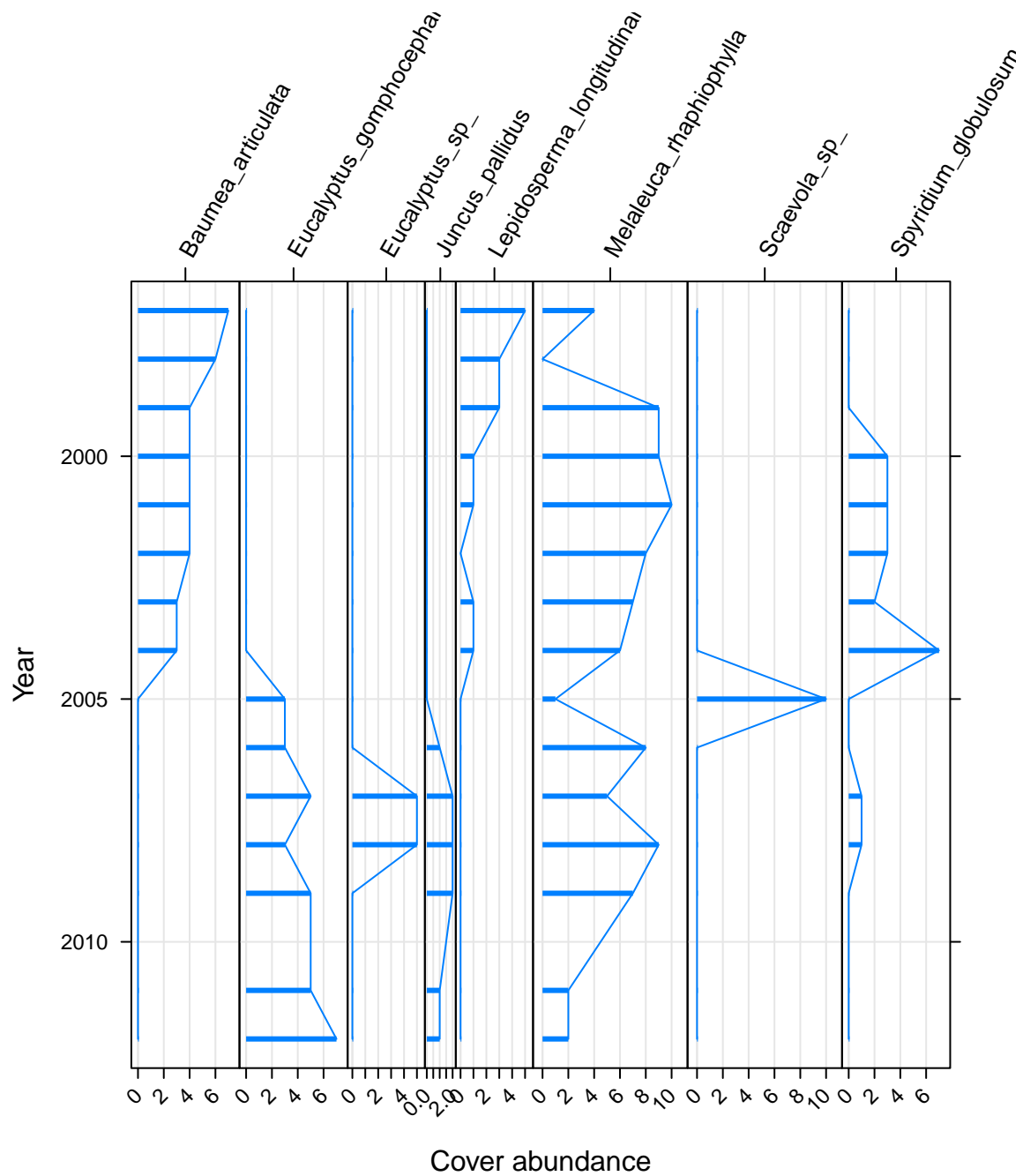
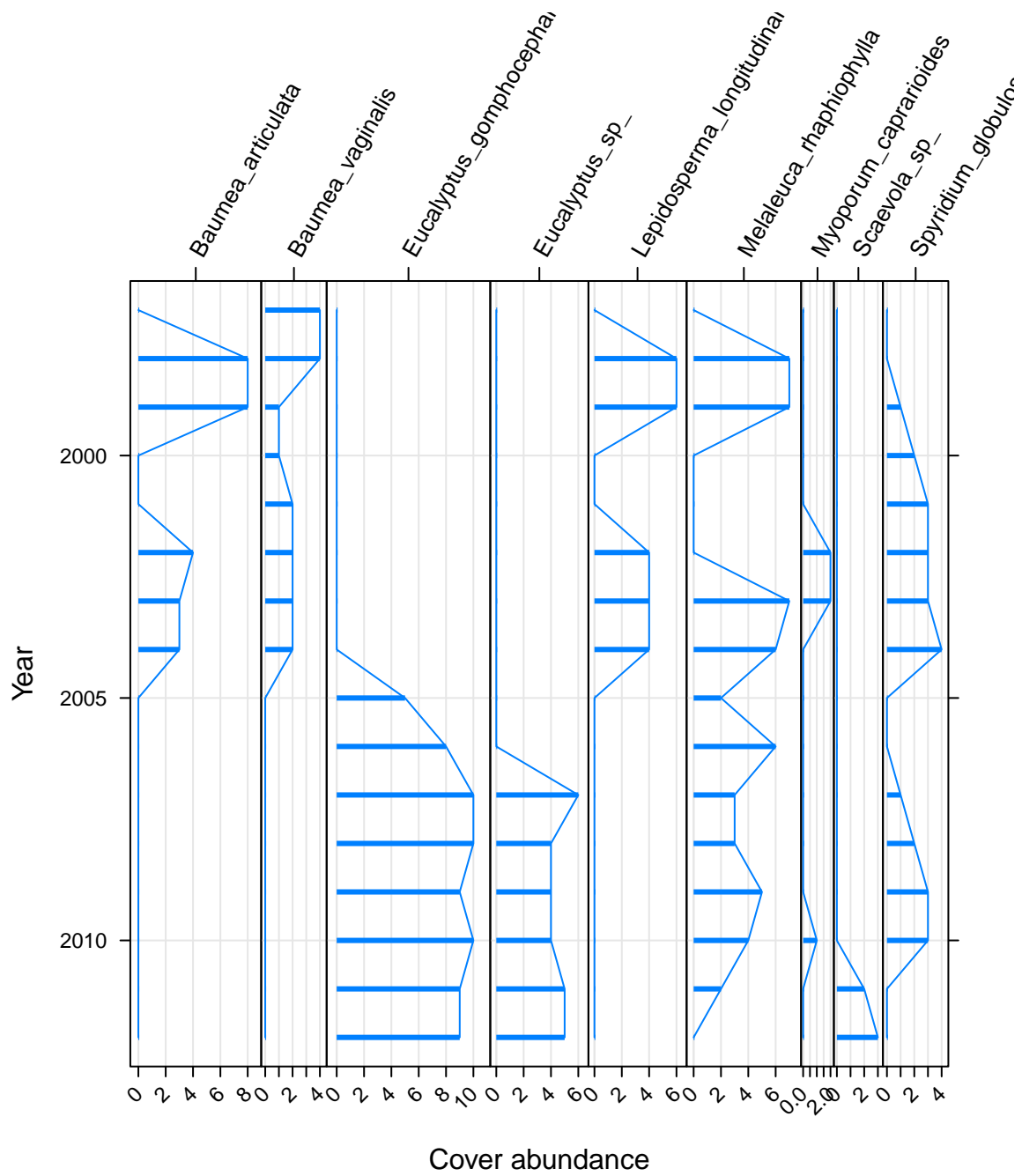
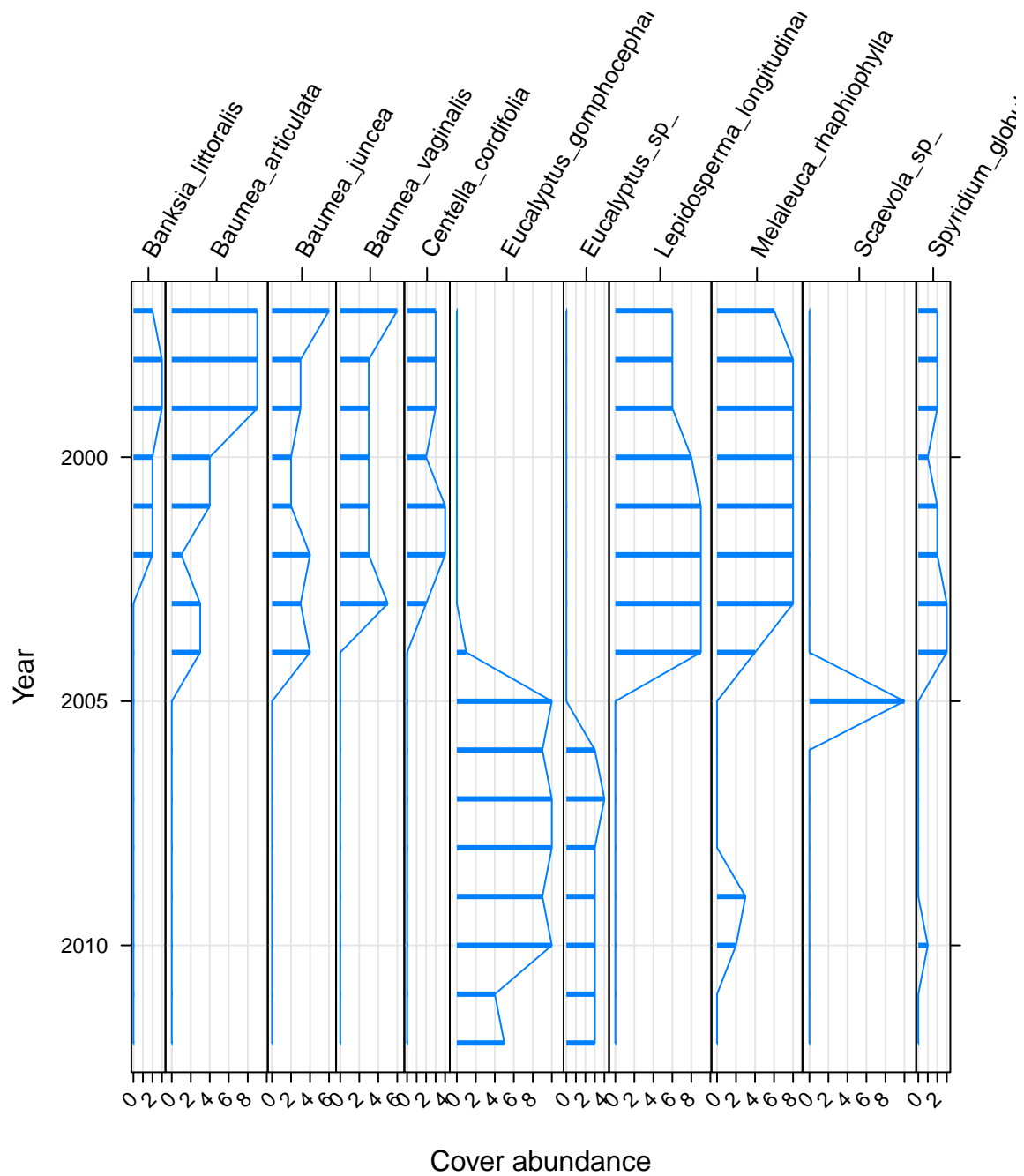
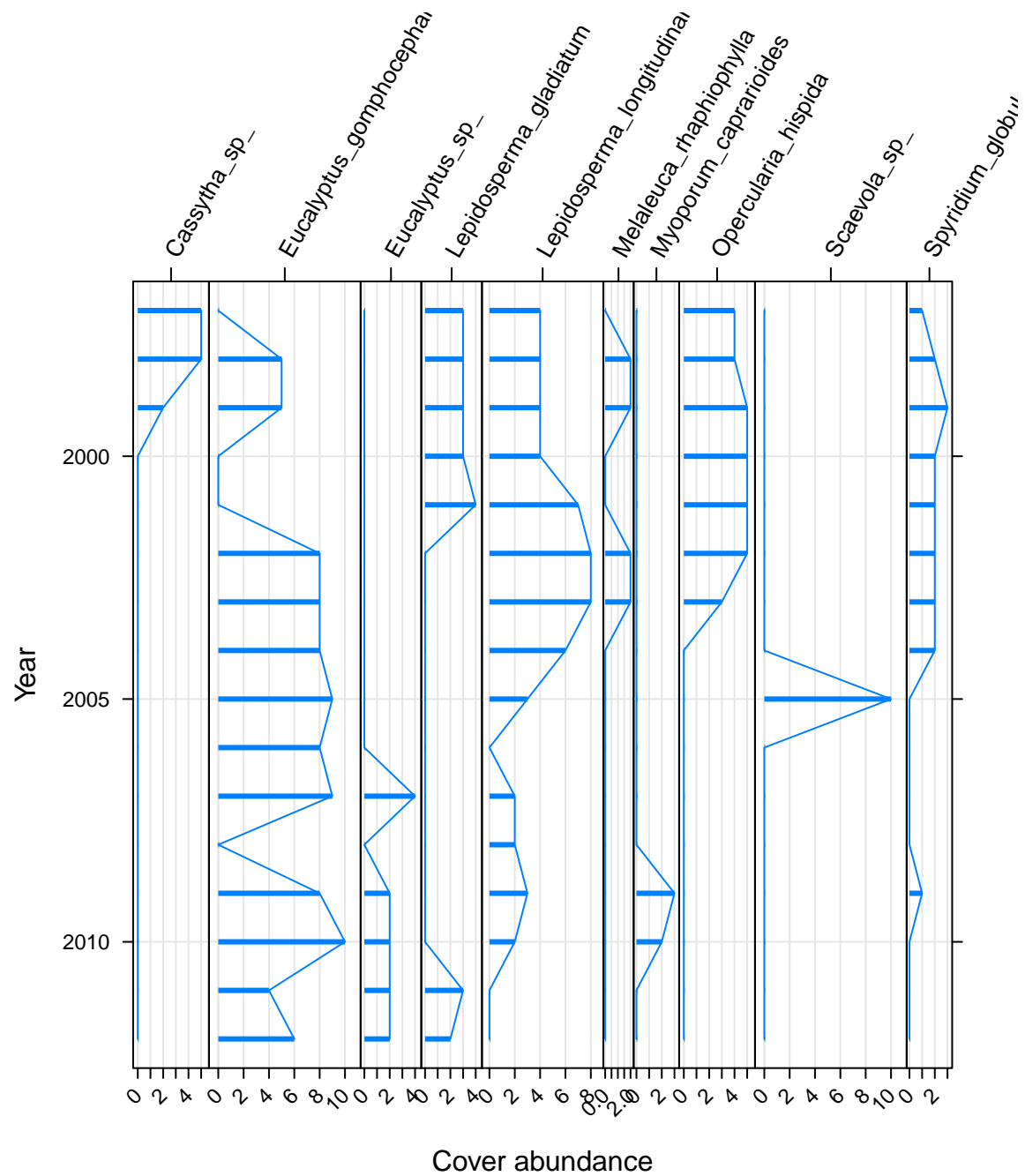


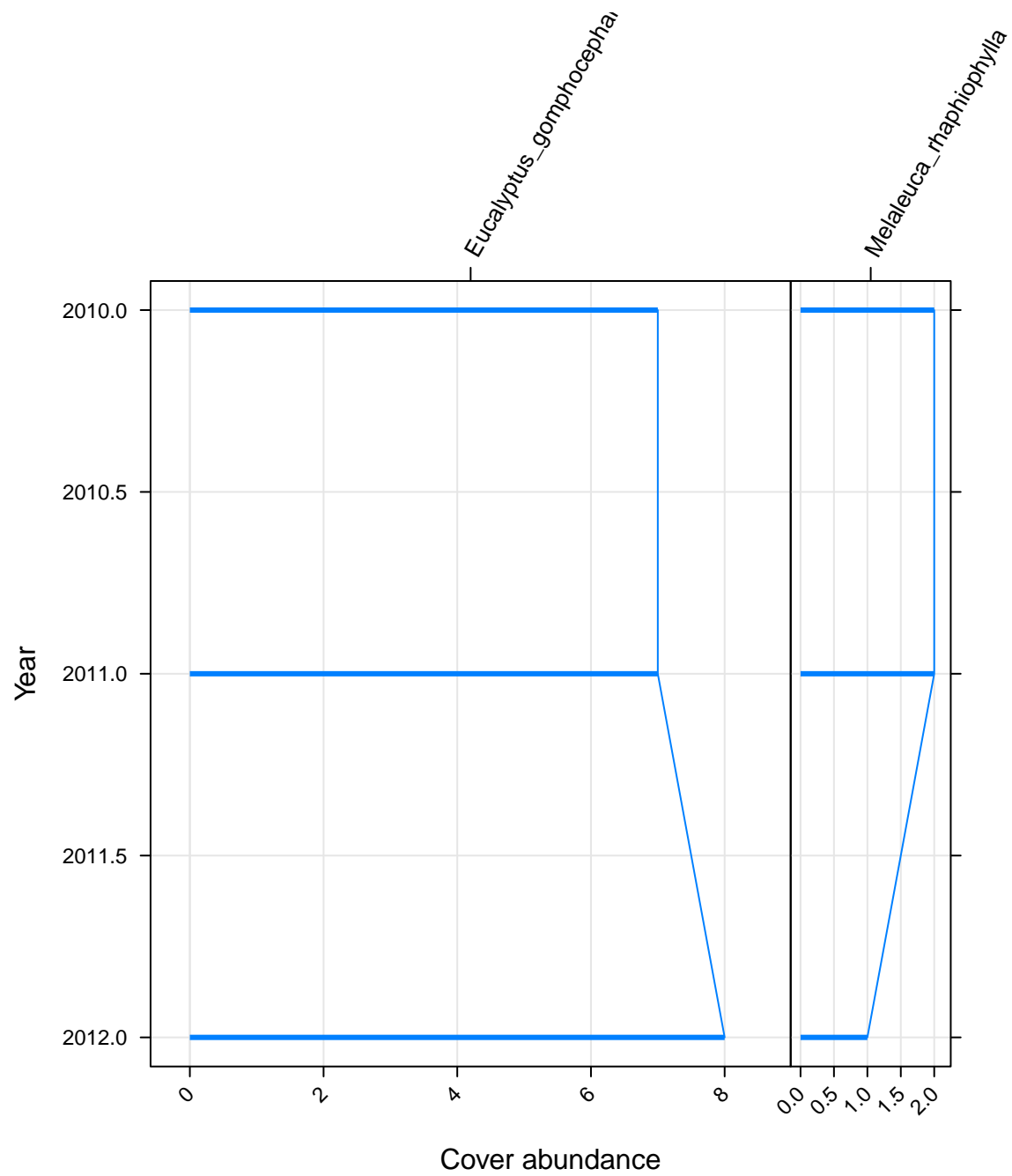
Figure 40: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Wilgarup

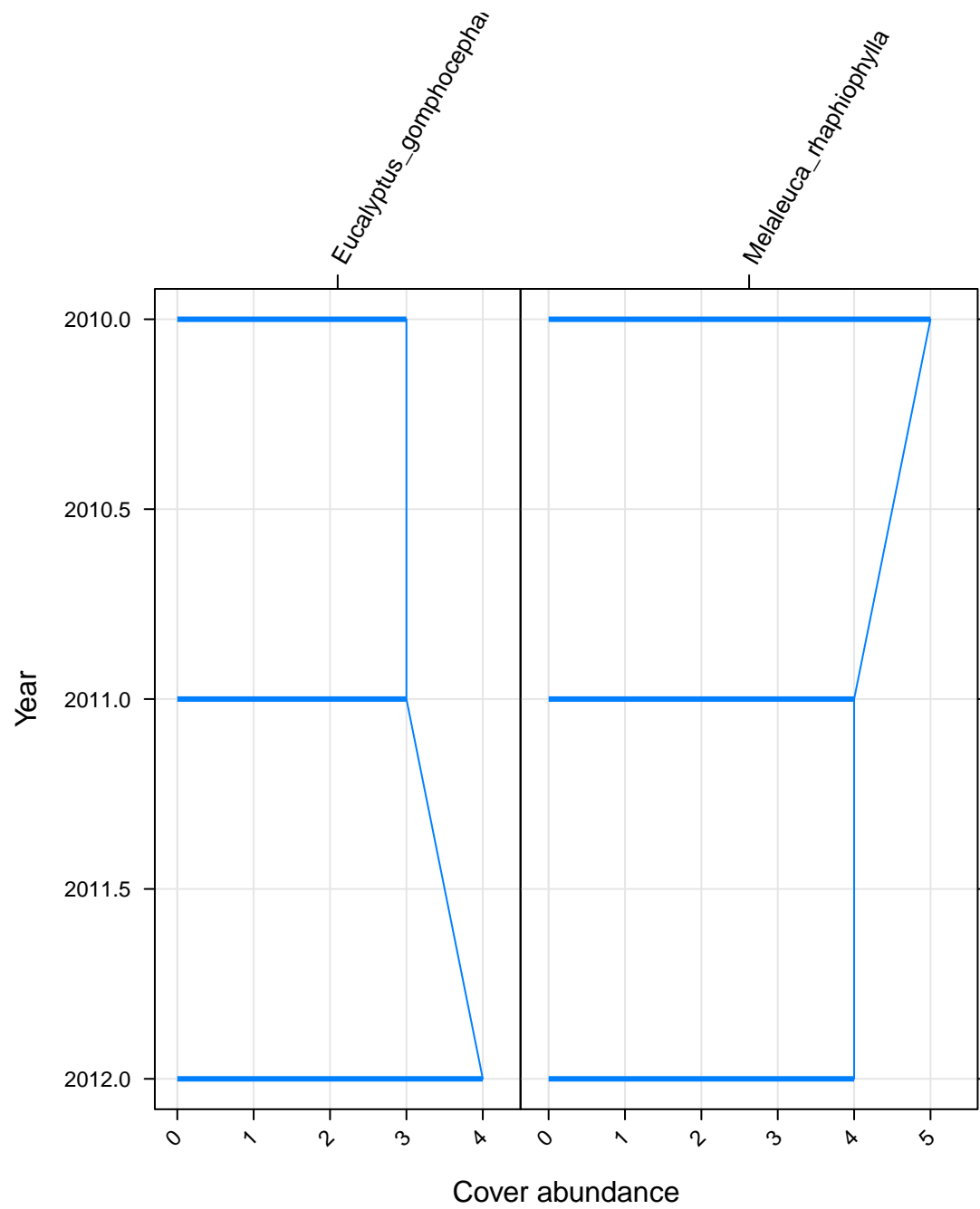












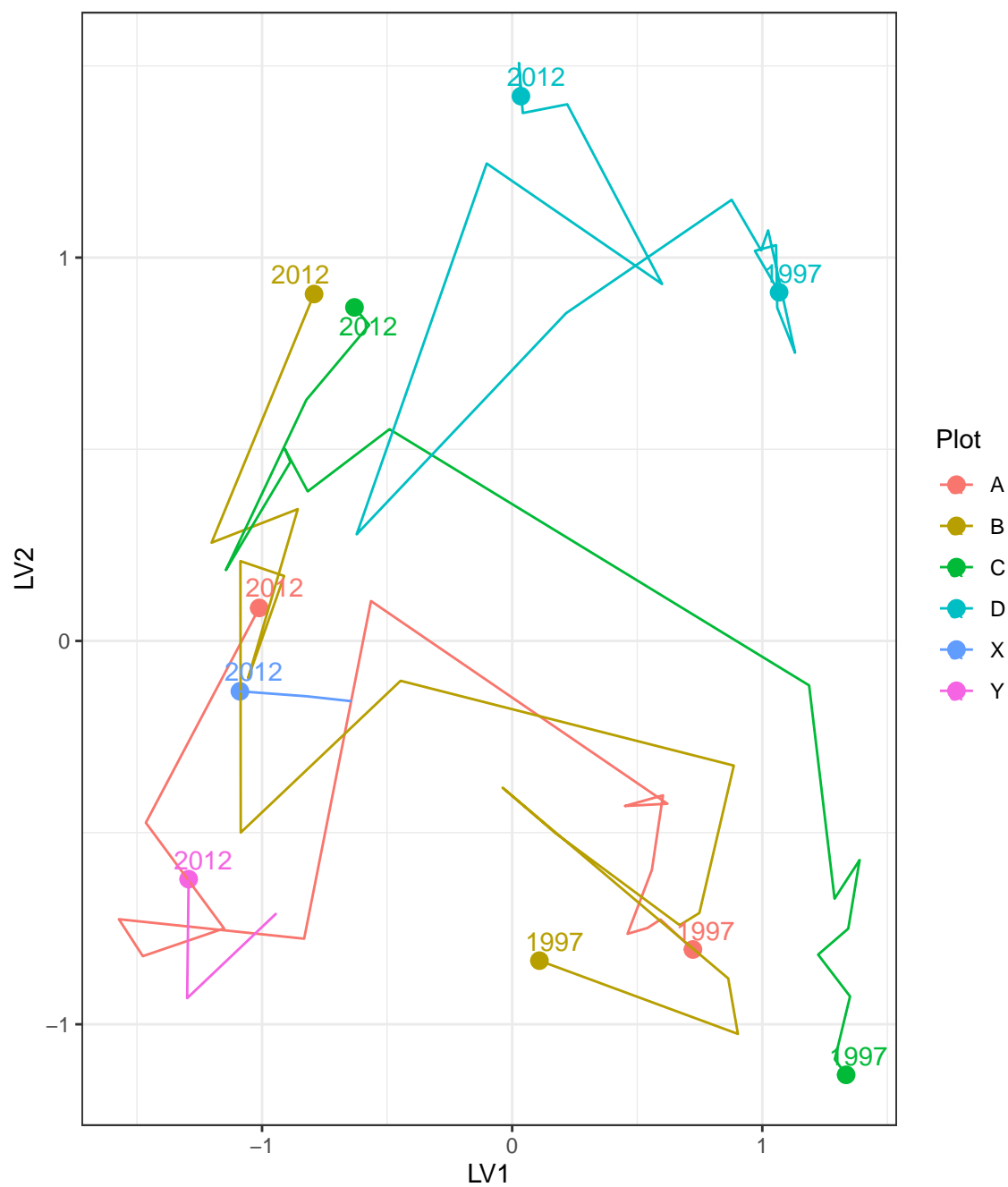


Figure 41: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

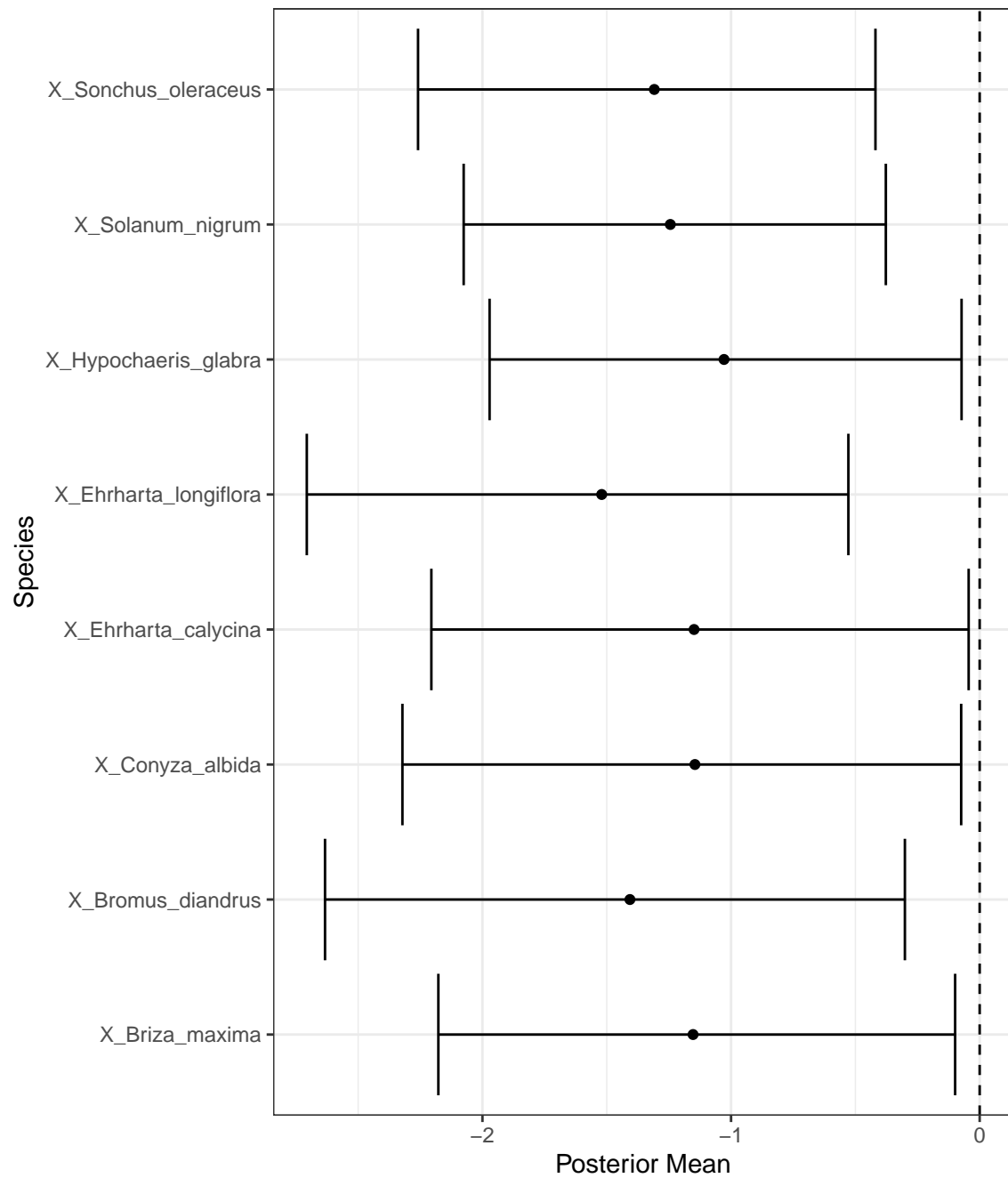


Figure 42: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown

WM1

Five year summaries of surface water level data at
EMP 173

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	51.122	50.209	0.913	October	March	195.667
08/1999 - 07/2004	51.086	50.410	0.676	September	April	157.600
08/2004 - 07/2009	51.036	50.410	0.626	August	January	79.000
08/2009 - 07/2014	50.732	50.400	0.332	October	February	60.800
08/2014 - 07/2019	50.804	50.400	0.404	September	January	85.600

WM2

Five year summaries of surface water level data at
WM2

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	51.122	50.209	0.913	October	March	195.667
08/1999 - 07/2004	51.086	50.410	0.676	September	April	157.600
08/2004 - 07/2009	51.036	50.410	0.626	August	January	79.000
08/2009 - 07/2014	50.732	50.400	0.332	October	February	60.800
08/2014 - 07/2019	50.804	50.400	0.404	September	January	85.600

WM8

Five year summaries of surface water level data at
WM8

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	66.313	65.661	0.652	October	July	230.200
08/1999 - 07/2004	66.013	65.485	0.528	December	June	180.000
08/2004 - 07/2009	65.609	65.209	0.400	November	July	256.000
08/2009 - 07/2014	65.007	64.651	0.356	November	August	200.200
08/2014 - 07/2019	65.029	64.703	0.326	December	July	29.600

Yonderup

Five year summaries of surface water level data at
Yonderup

Period	Mean max seasonal level (mAHD)	Mean min seasonal level (mAHD)	Mean seasonal change (m)	Month of maximum	Month of minimum	Mean max to min (days)
08/1994 - 07/1999	5.993	5.924	0.069	August	September	82.400
08/1999 - 07/2004	5.959	5.901	0.058	September	February	143.600
08/2004 - 07/2009	5.921	5.862	0.059	April	April	130.200
08/2009 - 07/2014	5.867	5.681	0.186	September	April	211.800
08/2014 - 07/2019	5.808	5.557	0.251	September	March	218.400

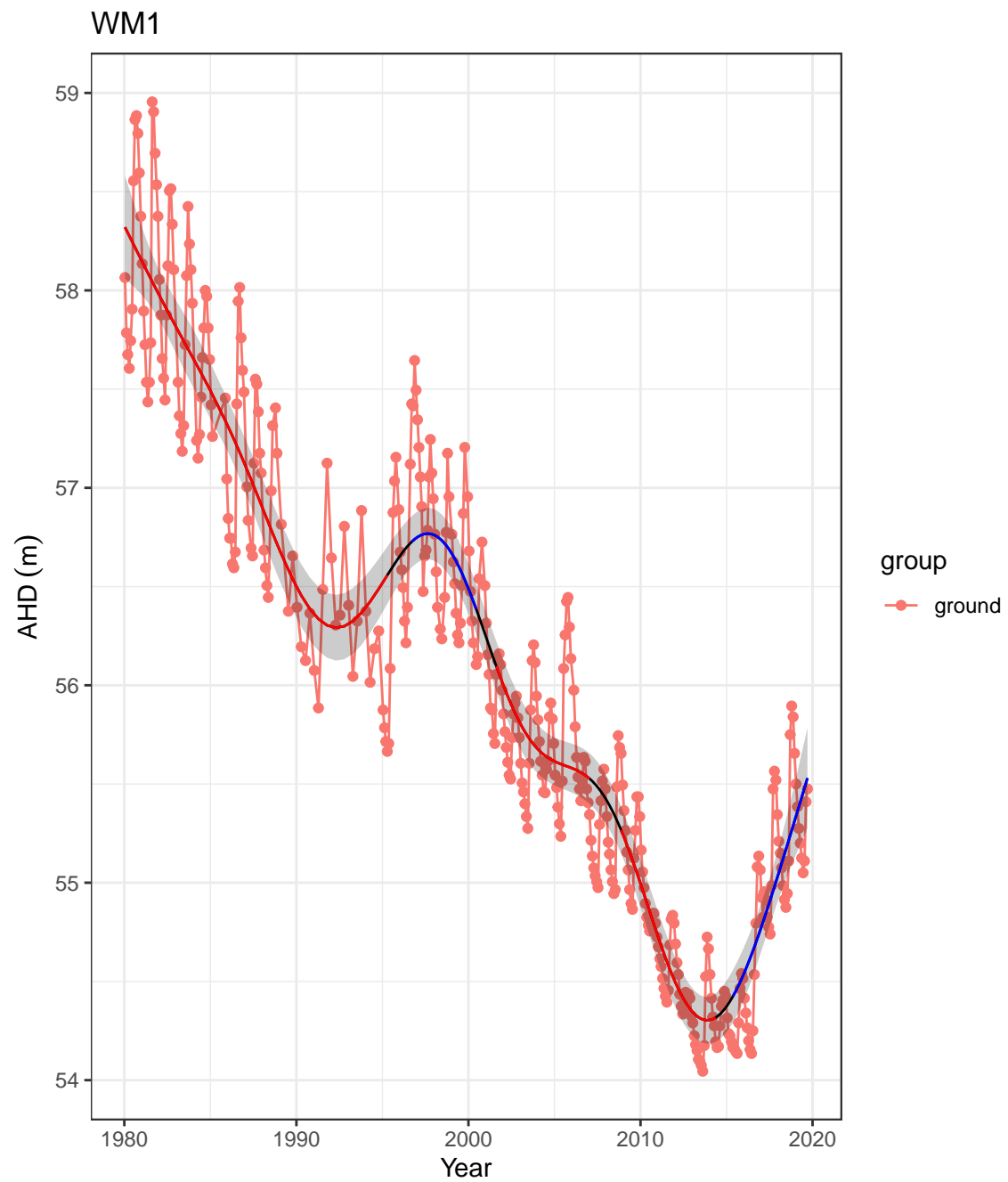


Figure 43: Ground and surface water levels recorded at bores and staff gauges in the vicinity of WM1

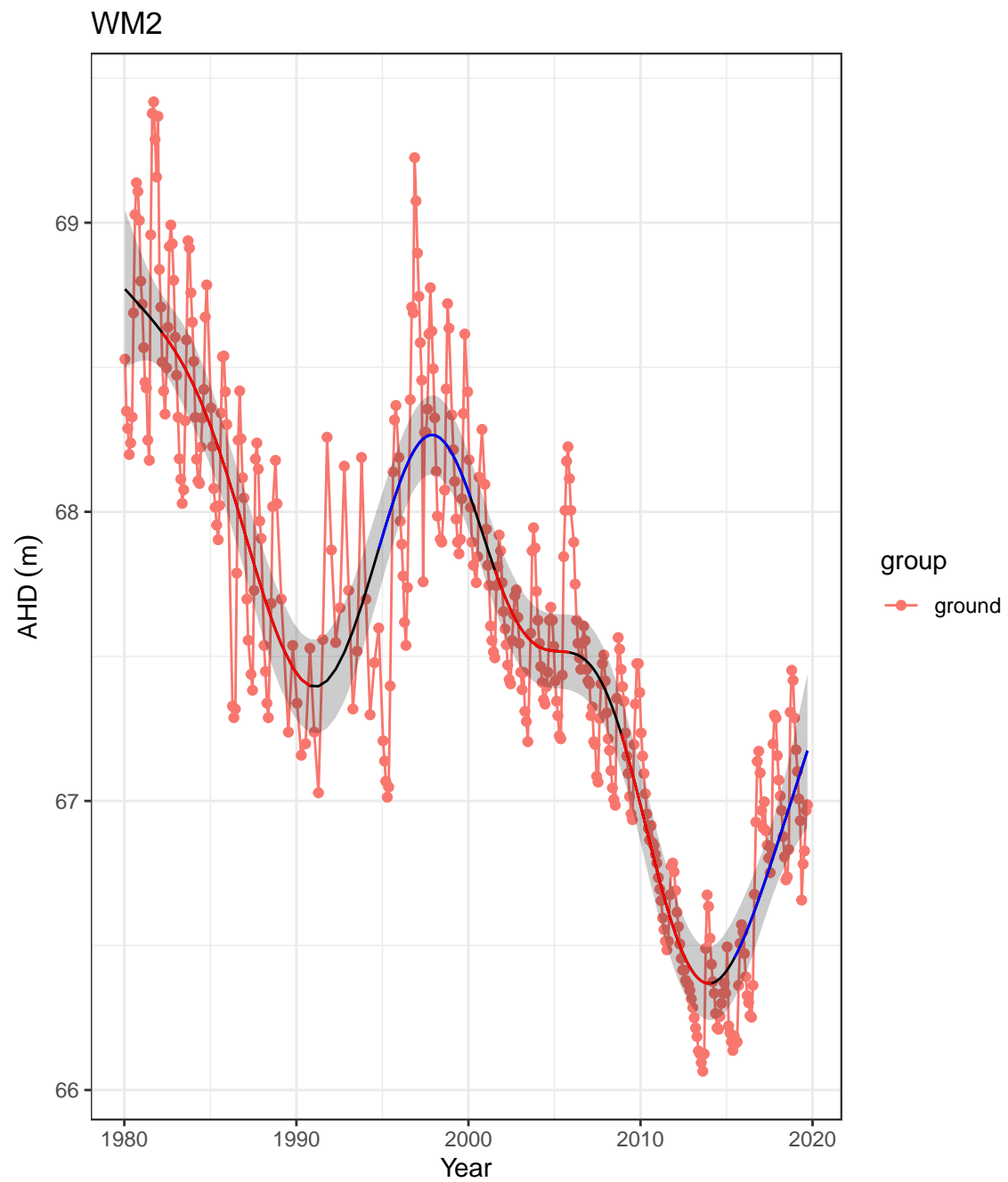


Figure 44: Ground and surface water levels recorded at bores and staff gauges in the vicinity of WM2

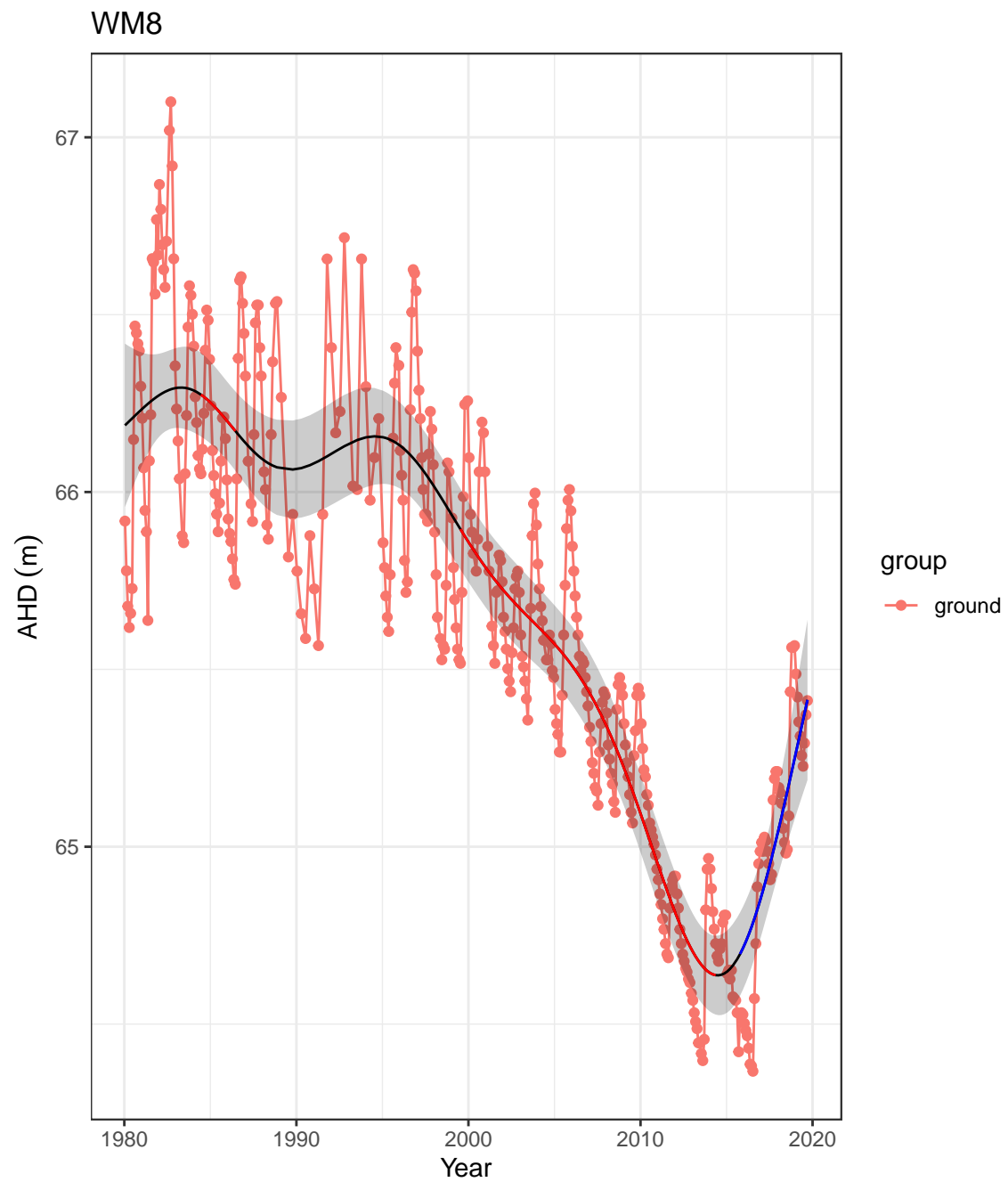


Figure 45: Ground and surface water levels recorded at bores and staff gauges in the vicinity of WM8

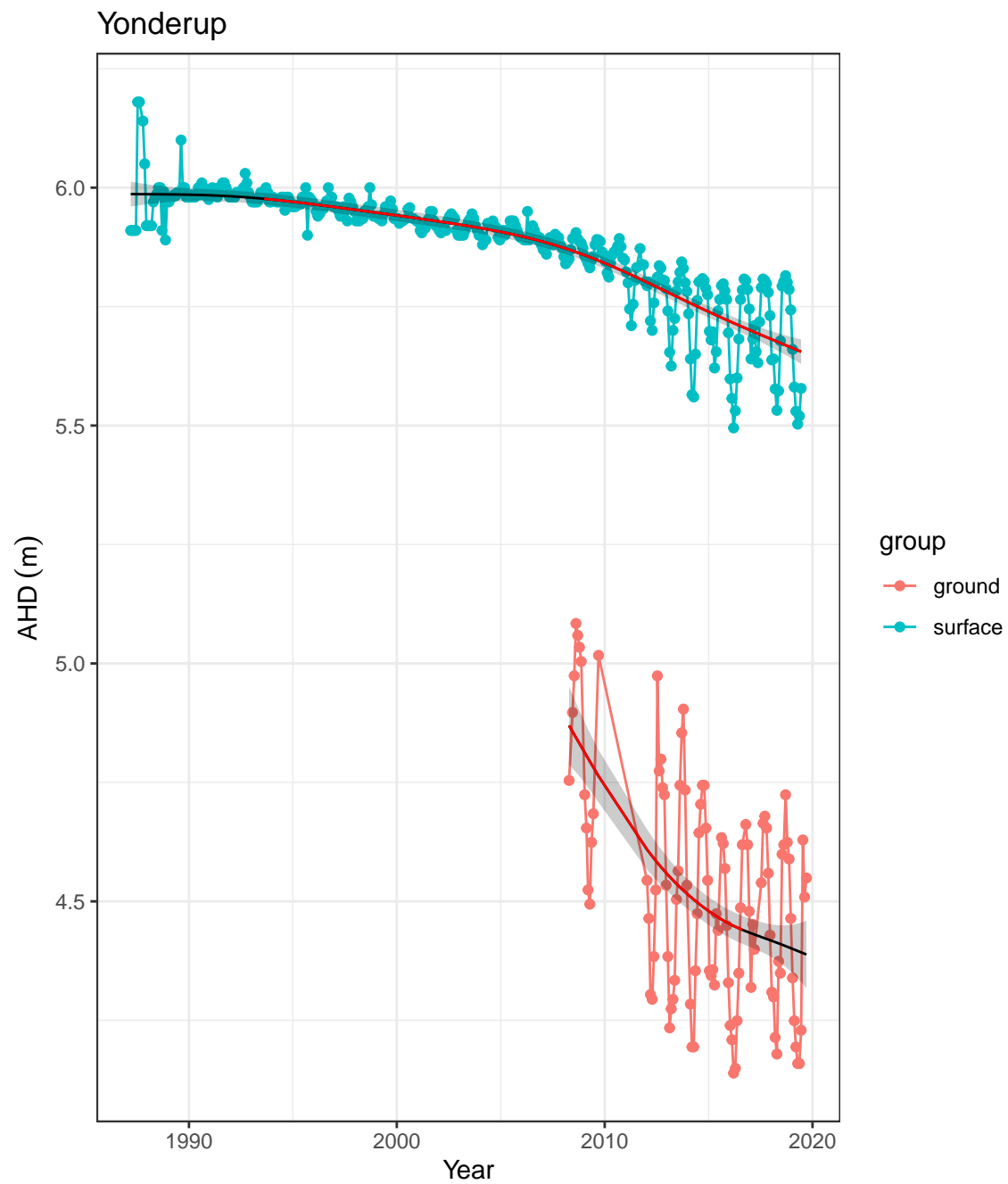
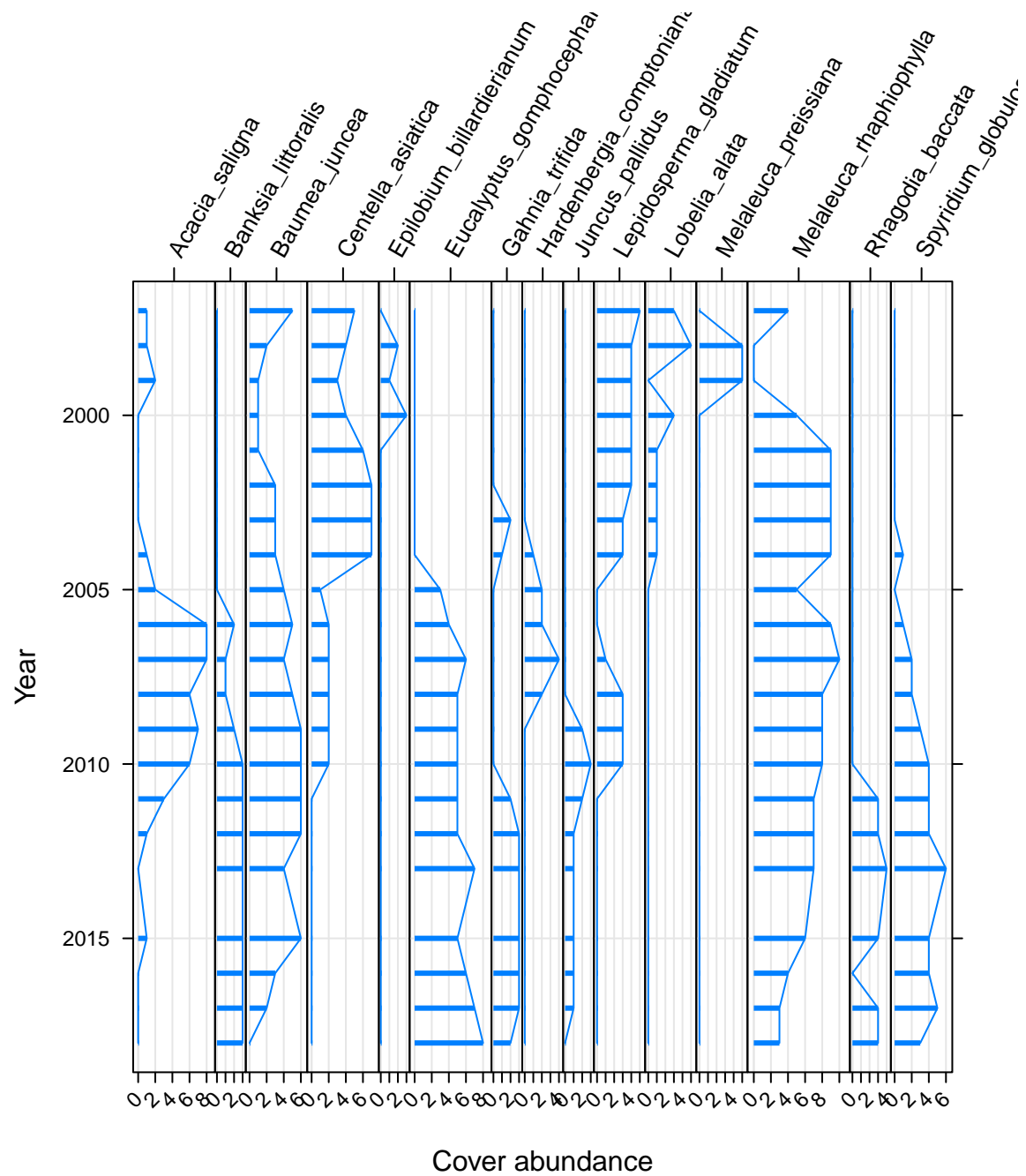
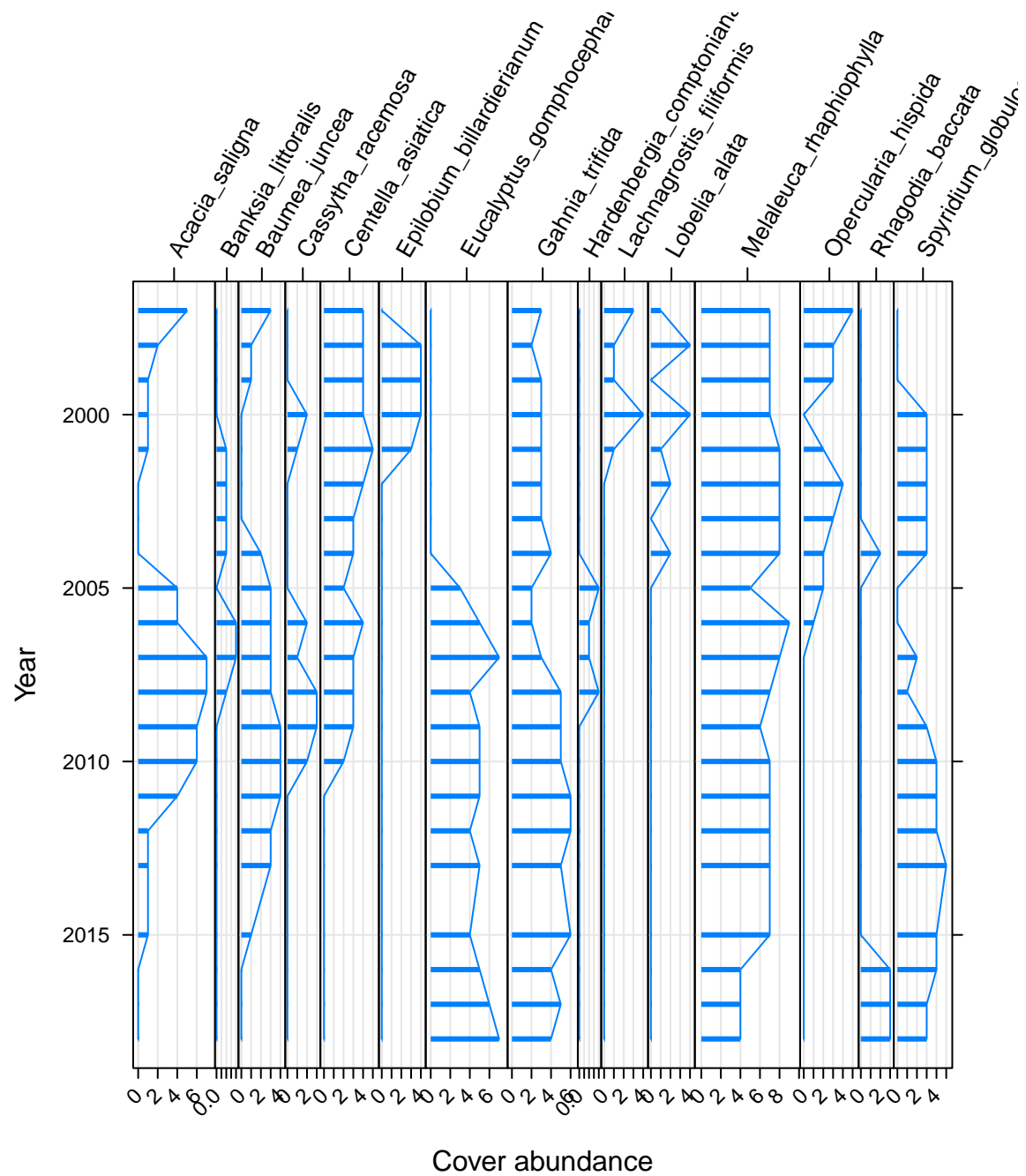
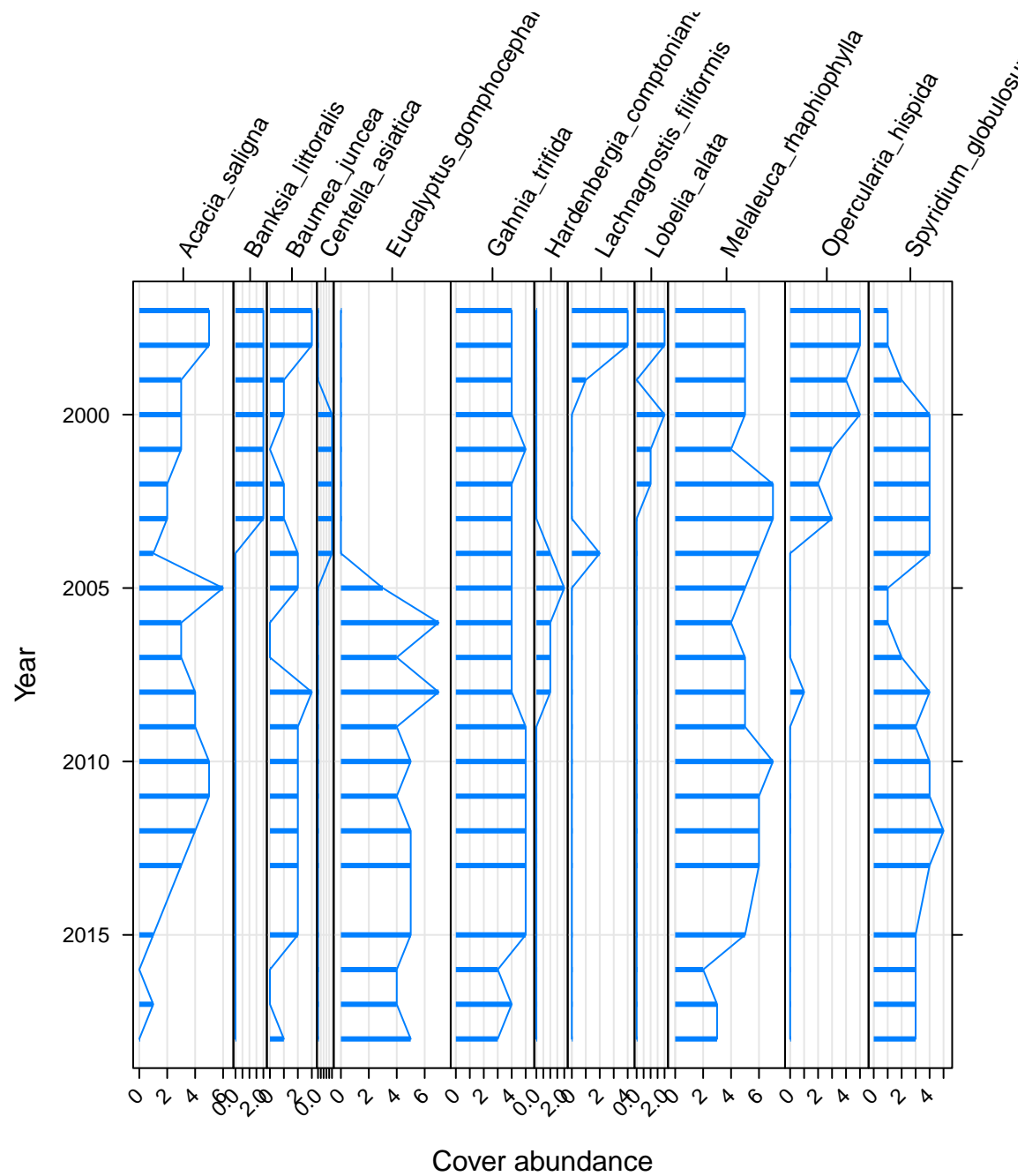
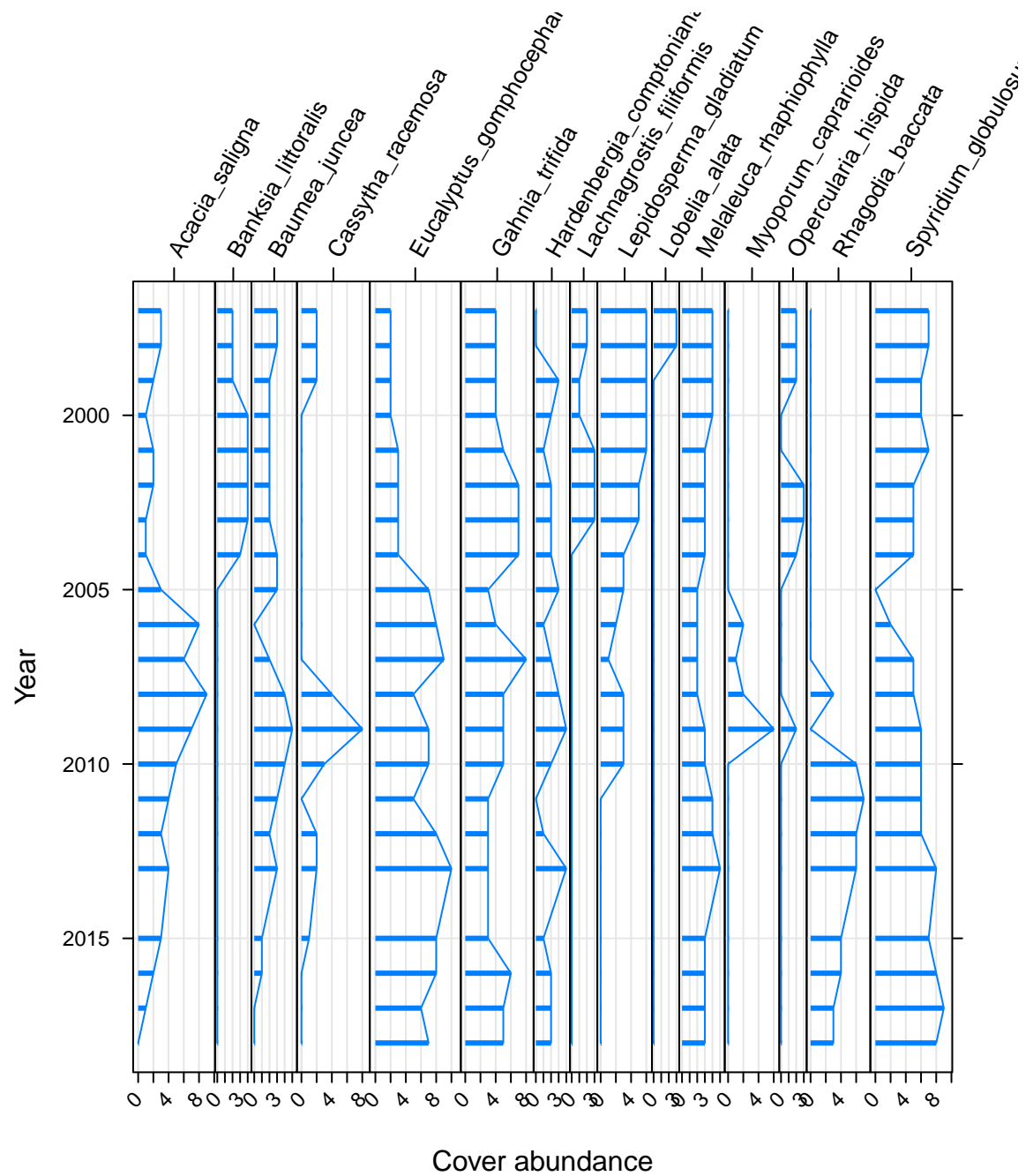


Figure 46: Ground and surface water levels recorded at bores and staff gauges in the vicinity of Yonderup









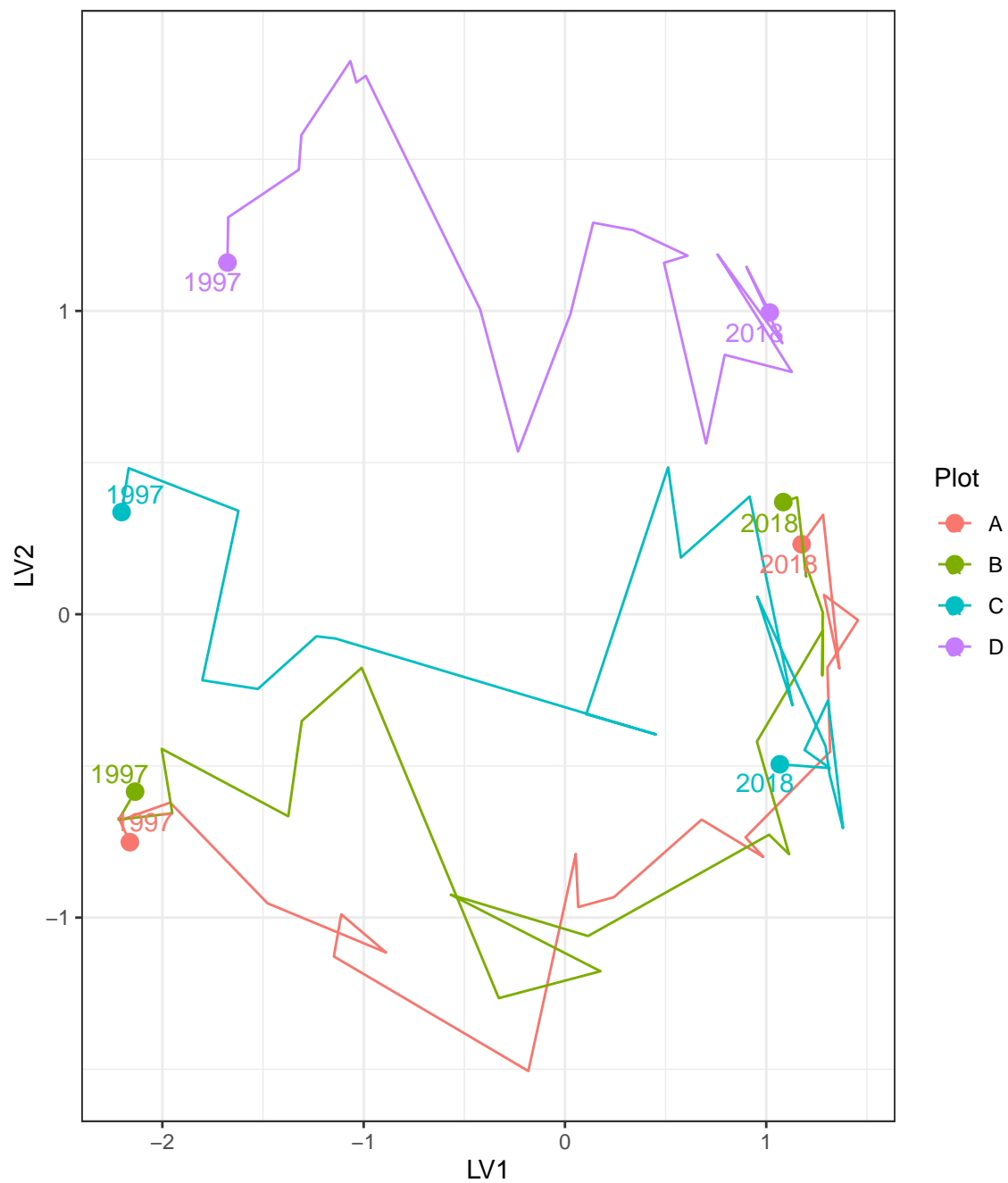


Figure 47: Ordination plot with full residual model on the left and a model on the right showing residual variation after the effect of groundwater levels were accounted for

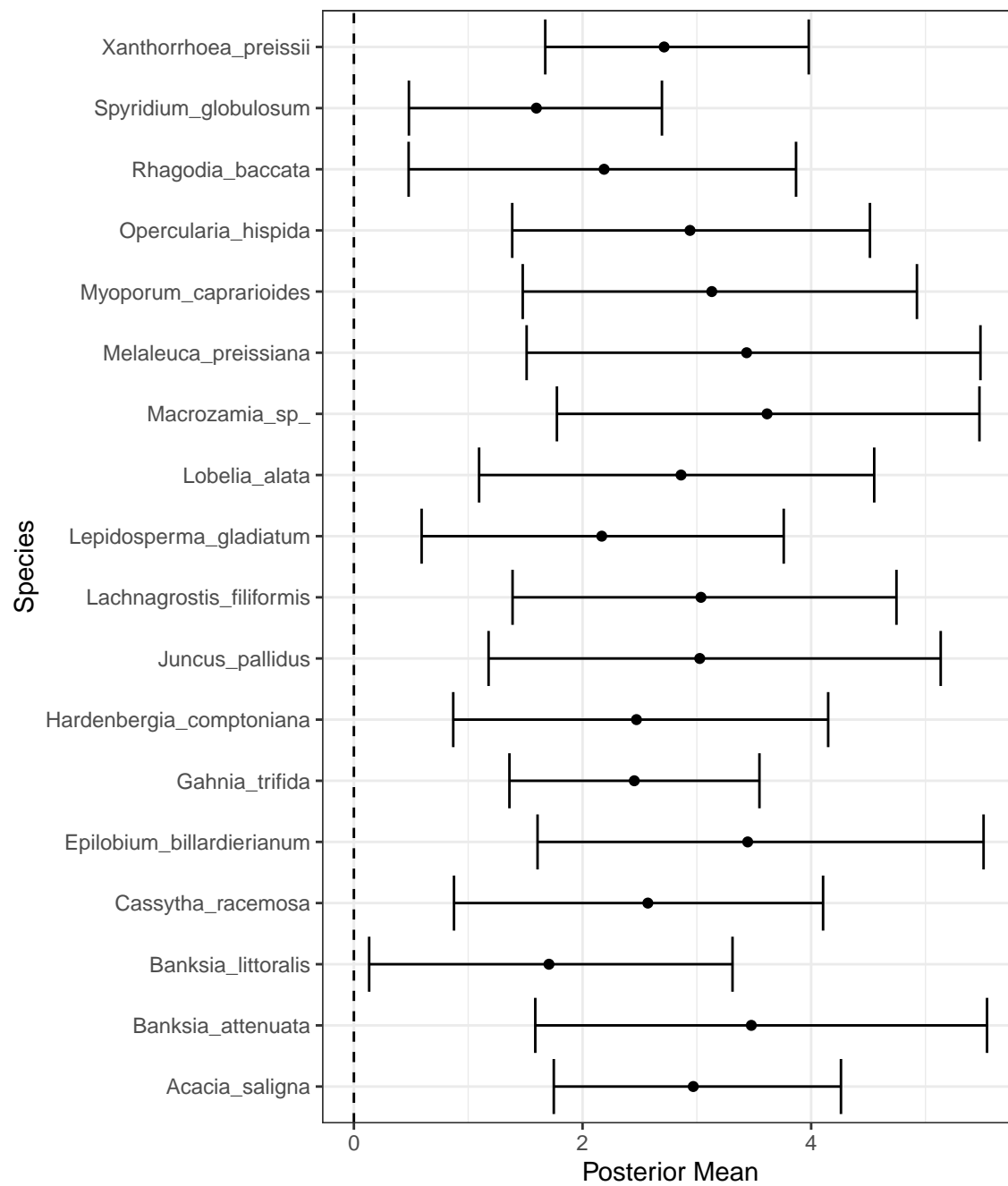


Figure 48: Mean regression coefficients (dots) and 95% credible intervals (bars) for effect of groundwater level on vegetation species cover abundances. Only those species with coefficients significantly different to zero are shown