

Supporting Information for “Cross-taxa analysis of long-term data reveals a positive biodiversity-stability relationship with taxon-specific mechanistic underpinning”

Table S1. Traits used to describe the pace-of-life and functional diversity in each taxon.

Taxon	Trait name	Description	Type	Function
Birds	Migration	Species migratory status: resident, short-distance migrant or long-distance migrant.	Categorical	Dispersal
	Generation length	Species generation length in years. (Log-transformed)	Continuous	Reproduction
	Body mass	Species body mass in grams. (Log-transformed)	Continuous	Growth
	Maximum brood	Maximum number of broods per year (Log-transformed).	Continuous	Reproduction
	Feeding	Diet category: insectivore, carnivore, herbivore, omnivore or mixed.	Categorical	Resource use
Butterflies and moths	Wintering life stage	The life history stage in which a species hibernates: egg, larvae, pupa or adult.	Categorical	Survival
	Voltinism	The number of generations a species has in a year: univoltine (one), bivoltine (two), multivoltine (three or more).	Categorical	Reproduction
	Host usage	The range of hostplants that a species can use: monophagous (one species), oligophagous (several species within one genus or family), polyphagous (several species and families.)	Categorical	Resource use
	Wingspan	Distance between the apices of the two forewings measured in millimetres. (Log-transformed)	Continuous	Dispersal and growth
Small and large mammals	Generation length	Average age of parents in days. (Log-transformed)	Continuous	Reproduction
	Litter size	Number of offspring born per litter per female.	Continuous	Reproduction
	Diet breadth	Number of different food elements a species consumes.	Continuous	Resource use
	Body mass	Species body mass in grams. (Log-transformed)	Continuous	Growth
	Dispersal distance	Distance in kilometers a species travels between the birth and breeding site. (Log-transformed)	Continuous	Dispersal
Phytoplankton	Nitrogen fixation	Species ability to fix nitrogen, which can provide a competition advantage.	Binary	Resource use
	Motility	Species ability to move and migrate.	Binary	Dispersal
	Colony formation	Larger cell sizes (i.e., ability to form colonies) decrease grazing pressure and reduce mortality.	Binary	Survival
	Cell volume	Species size measured in micrometers cubed.	Continuous	Growth

Table S2. References of bird trait data. Full reference is provided when first mentioned and after that only citation is shown.

Trait	References
Migratory status	Valkama, J. Saurola, P. Lehtikoinen, A. Lehtikoinen, E. Piha, M. Sola, P. and Velmala, W. (2014). <i>The Finnish Bird Ringing Atlas</i> . Vol. II. Finnish Museum of Natural History and Ministry of Environment, Helsinki.
Generation length	
Body mass	Cramp, S., Simmons, K.E.L., Perrins, C.M. (1977-1994). <i>Handbook of the Birds of Europe, the Middle East and North Africa: Birds of the Western Palearctic</i> . Oxford University Press, Oxford. Piha, M. & Lehtikoinen, E. (2016). Body mass and wing length of birds based on the Finnish ringing database — Part 1: non-corvid passerines. <i>Linnut-vuosikirja 2015</i> :142-151.
Maximum brood	Cramp et al. (1977-1994) Solonen, T. (1985). <i>Suomen Linnusto: Esiintyminen ja perusbiologia</i> , 280 p. Lintutieto.
Feeding	Brommer, J. (2008). Extent of recent polewards range margin shifts in Finnish birds depends on their body mass and feeding ecology. <i>Ornis Fennica</i> 85: 105-117. Cramp et al. (1977-1994) Wilman, H., Belmaker, J., Simpson, J., de la Rosa, C., Rivadeneira, M. M. & Jetz, W. (2014). EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals. <i>Ecology</i> 95:2027. http://dx.doi.org/10.1890/13-1917.1

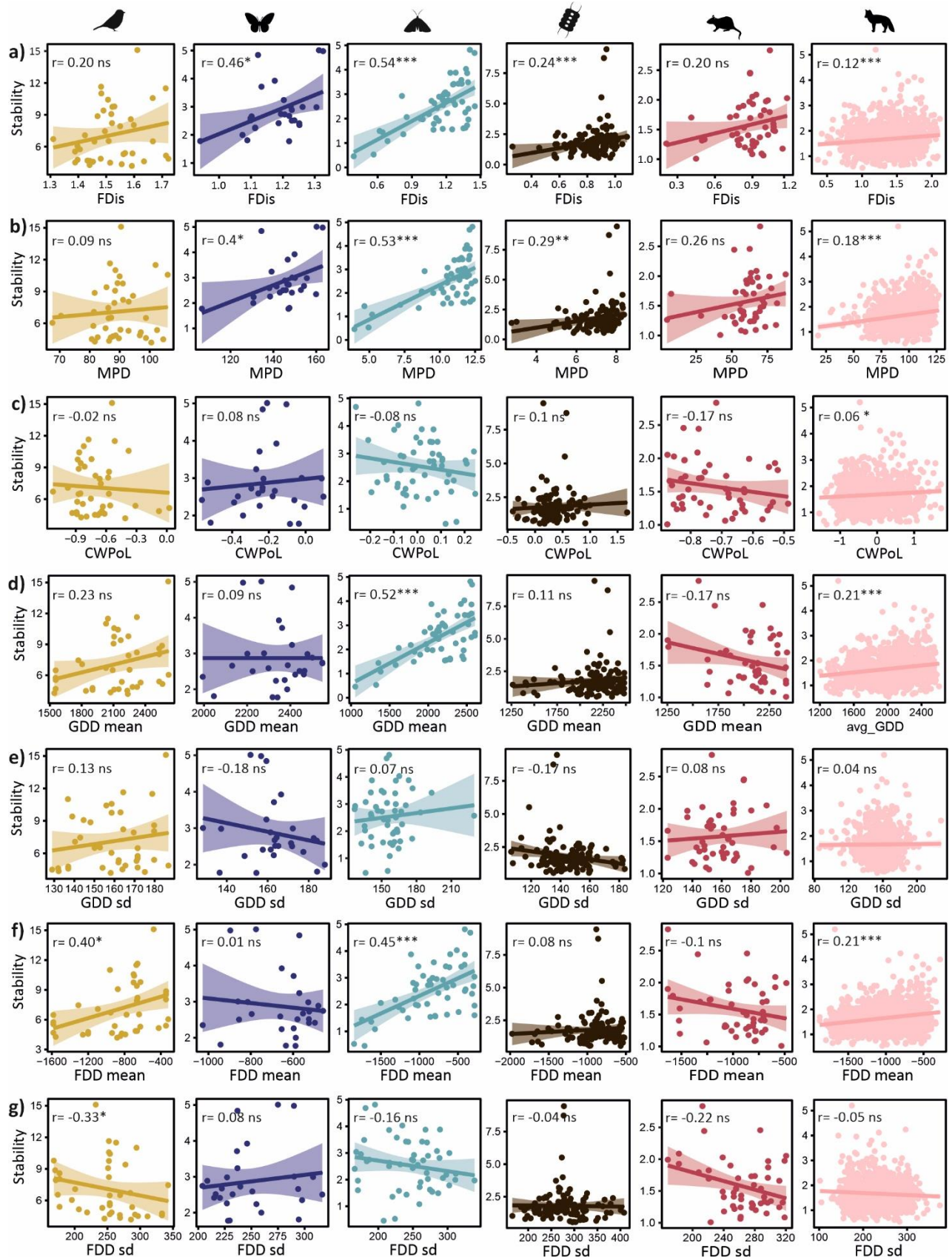
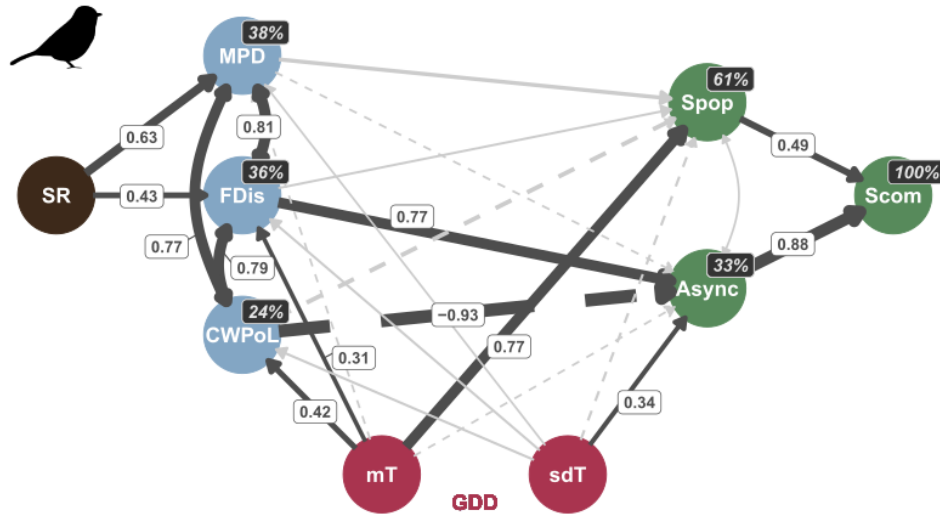


Figure S2. The relationships between community stability and functional dispersion (FD; a), mean phylogenetic distance (MPD; b), community weighted pace-of-life traits (CWPoL; c) as well as mean and standard deviation of growing degree (GDD; d-e) and freezing degree days (FDD; f-g) across taxa. Trend line visualized the linear relationship between the variables and correlation is reported using the Spearman correlation coefficient (r). Statistical significance is marked with asterisk (* = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$, ns = not significant).

Birds (GDD)

Fischer's C = 26.883; df = 18; p-value = 0.081
 Chi-square = 12.123; df = 9; p-value = 0.206
 AICc = -2371.525



Birds (FDD)

Fischer's C = 34.121; df = 18; p-value = 0.012
 Chi-square = 14.683; df = 9; p-value = 0.1
 AICc = -2372.314

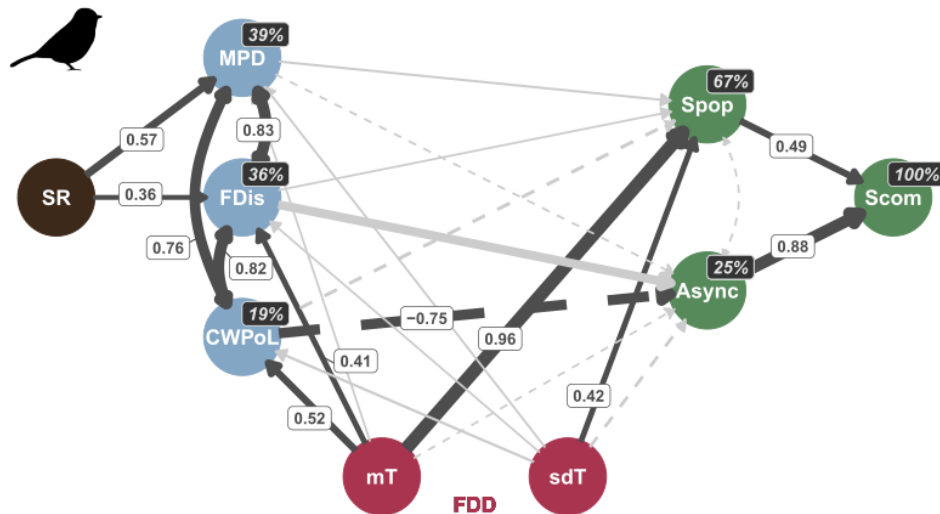
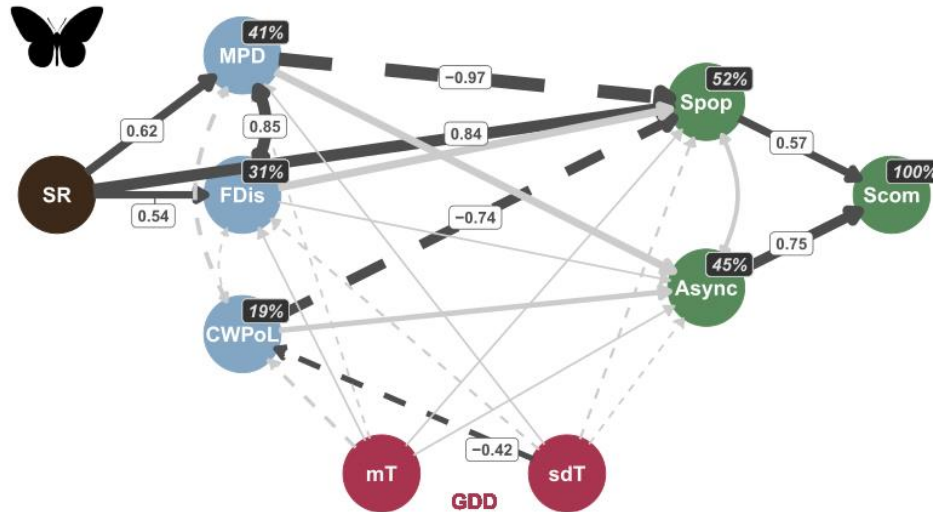


Figure S3 - Structural equation models for bird data using growing degree days (GDD) and freezing degree days (FDD) as temperature variable. Straight lines represent causal paths while curved lines represent correlation terms. Black arrows show significant effect – for which coefficients are shown in a white background box – while grey arrows show non-significant effect. Arrow width represents the effect size; solid arrows represent a positive effect and dashed arrows show a negative effect. Boxes with black background show the R² (%) for each response variable in the model. Coloured circles follow the standard model components where black refers to species richness, blue to traits, red to environment and green to ecosystem function. SR = species richness, FDis = functional dispersion, MPD = mean phylogenetic distance, CWPoL = community weighted pace-of-life, mT = temporal mean of temperature, sdT = temporal standard deviation of temperature, FDD = freezing degree days, GDD = growing degree days, S_{pop} = weighted average population stability, Async = asynchrony, S_{com} = community stability.

Butterflies (GDD)

Fischer's C = 15.63; df = 16; p-value = 0.479
 Chi-square = 6.806; df = 8; p-value = 0.558
 AICc = -1609.331



Butterflies (FDD)

Fischer's C = 13.012; df = 16; p-value = 0.672
 Chi-square = 5.452; df = 8; p-value = 0.708
 AICc = -1612.72

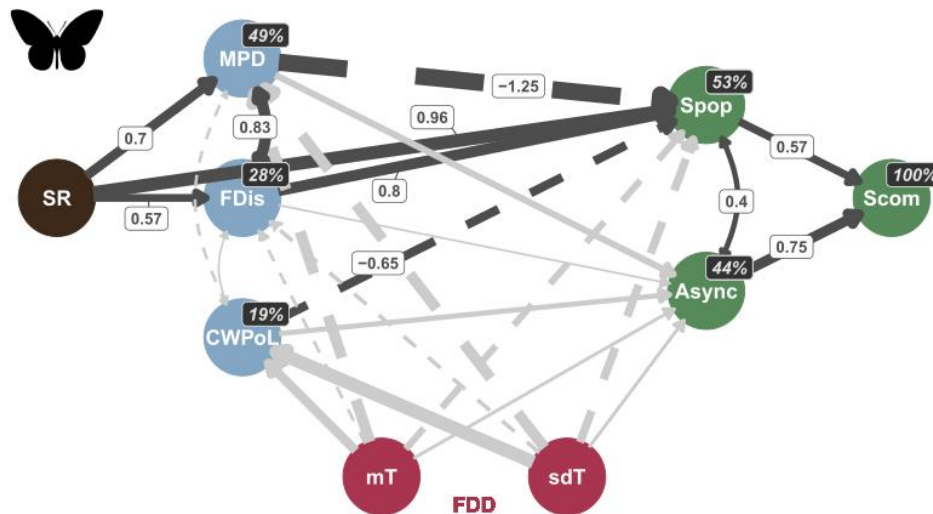
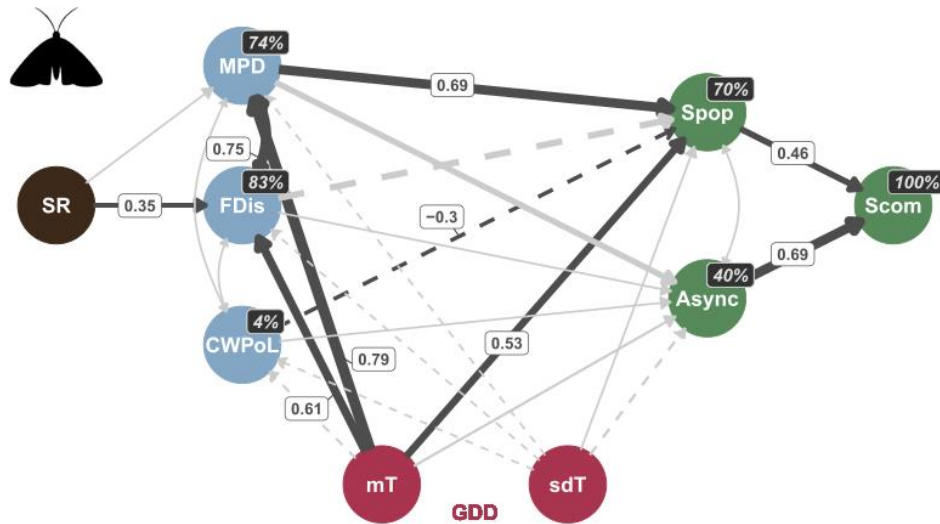


Figure S4 - Structural equation models for butterfly data using growing degree days (GDD) and freezing degree days (FDD) as temperature variable. Straight lines represent causal paths while curved lines represent correlation terms. Black arrows show significant effect – for which coefficients are shown in a white background box – while grey arrows show non-significant effect. Arrow width represents the effect size; solid arrows represent a positive effect and dashed arrows show a negative effect. Boxes with black background show the R² (%) for each response variable in the model. Coloured circles follow the standard model components where black refers to species richness, blue to traits, red to environment and green to ecosystem function. SR = species richness, FDis = functional dispersion, MPD = mean phylogenetic distance, CWPoL = community weighted pace-of-life, mT = temporal mean of temperature, sdT = temporal standard deviation of temperature, FDD = freezing degree days, GDD = growing degree days, S_{pop} = weighted average population stability, Async = asynchrony, S_{com} = community stability.

Moths (GDD)

Fischer's C = 13.785; df = 18; p-value = 0.743
 Chi-square = 7.231; df = 9; p-value = 0.613
 AICc = -3343.787



Moths (FDD)

Fischer's C = 7.193; df = 18; p-value = 0.988
 Chi-square = 3.031; df = 9; p-value = 0.963
 AICc = -3325.279

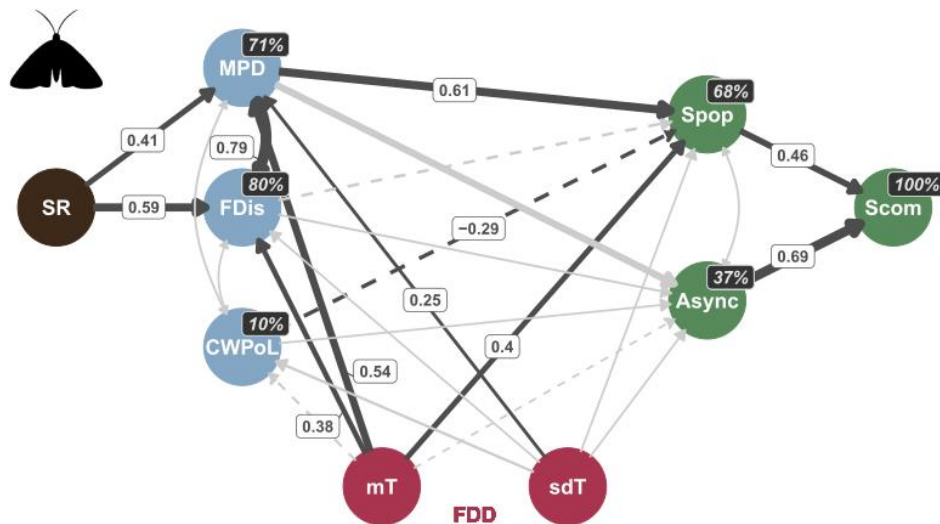
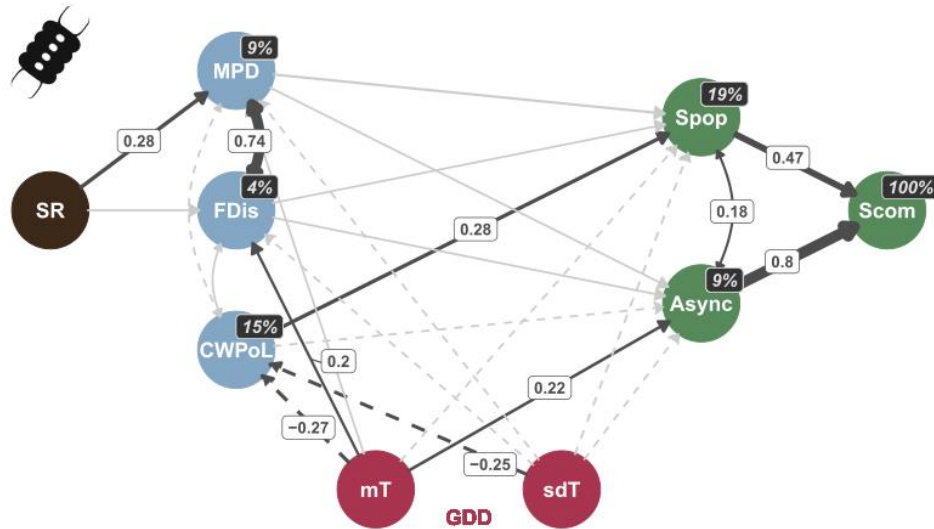


Figure S5 - Structural equation models for moth data using Growing Degree Days (GDD) and Freezing Degree Days (FDD) as temperature variable. Straight lines represent causal paths while curved lines represent correlation terms. Black arrows show significant effect – for which coefficients are shown in a white background box – while grey arrows show non-significant effect. Arrow width represents the effect size; solid arrows represent a positive effect and dashed arrows show a negative effect. Boxes with black background show the R² (%) for each response variable in the model. Boxes with black background show the R² (%) for each response variable in the model. Coloured circles follow the standard model components where black refers to species richness, blue to traits, red to environment and green to ecosystem function. SR = species richness, FDis = functional dispersion, MPD = mean phylogenetic distance, CWPoL = community weighted pace-of-life, mT = temporal mean of temperature, sdT = temporal standard deviation of temperature, FDD = freezing degree days, GDD = growing degree days, Spop = weighted average population stability, Async = asynchrony, Scom = community stability.

Phytoplankton (GDD)

Fischer's C = 7.119; df = 18; p-value = 0.989
 Chi-square = 3.124; df = 9; p-value = 0.959
 AICc = -7313.255



Phytoplankton (FDD)

Fischer's C = 7.283; df = 18; p-value = 0.988
 Chi-square = 3.132; df = 9; p-value = 0.959
 AICc = -7302.004

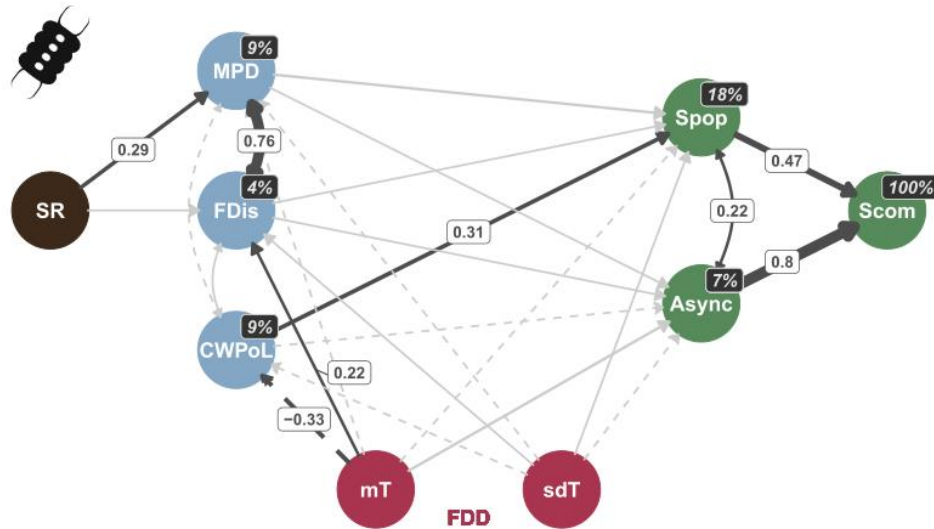
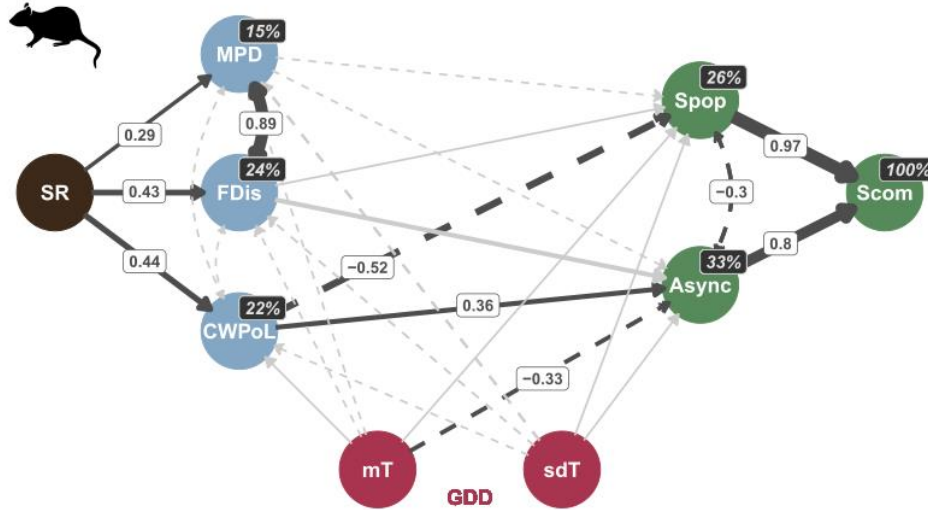


Figure S6 - Structural equation models for phytoplankton data using Growing Degree Days (GDD) and Freezing Degree Days (FDD) as temperature variable. Straight lines represent causal paths while curved lines represent correlation terms. Black arrows show significant effect – for which coefficients are shown in a white background box – while grey arrows show non-significant effect. Arrow width represents the effect size; solid arrows represent a positive effect and dashed arrows show a negative effect. Boxes with black background show the R² (%) for each response variable in the model. Coloured circles follow the standard model components where black refers to species richness, blue to traits, red to environment and green to ecosystem function. . SR = species richness, FDis = functional dispersion, MPD = mean phylogenetic distance, CWPol = community weighted pace-of-life, mT = temporal mean of temperature, sdT = temporal standard deviation of temperature, FDD = freezing degree days, GDD = growing degree days, S_{pop} = weighted average population stability, Async = asynchrony, S_{com} = community stability.

Small Mammals (GDD)

Fischer's C = 23.644; df = 16; p-value = 0.098
 Chi-square = 14.955; df = 8; p-value = 0.06
 AICc = -2917.958



Small Mammals (FDD)

Fischer's C = 23.612; df = 16; p-value = 0.098
 Chi-square = 15.02; df = 8; p-value = 0.059
 AICc = -2916.038

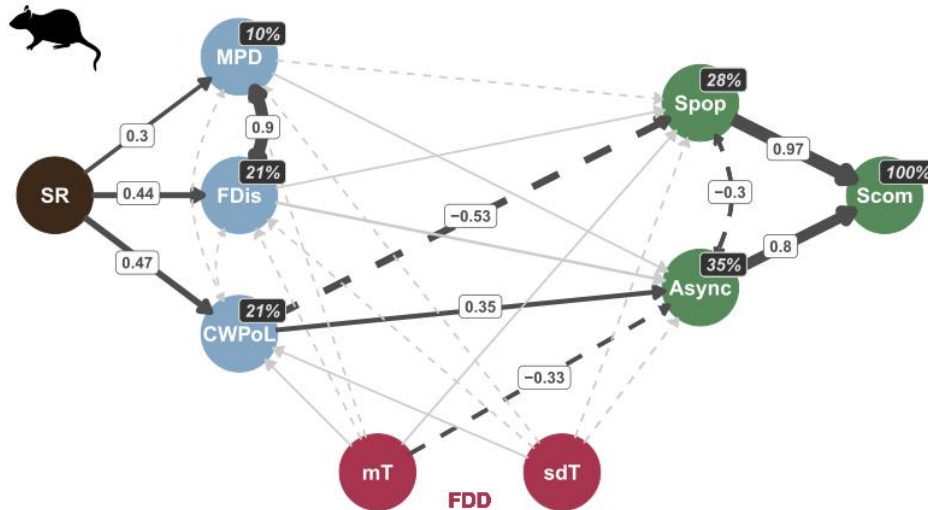
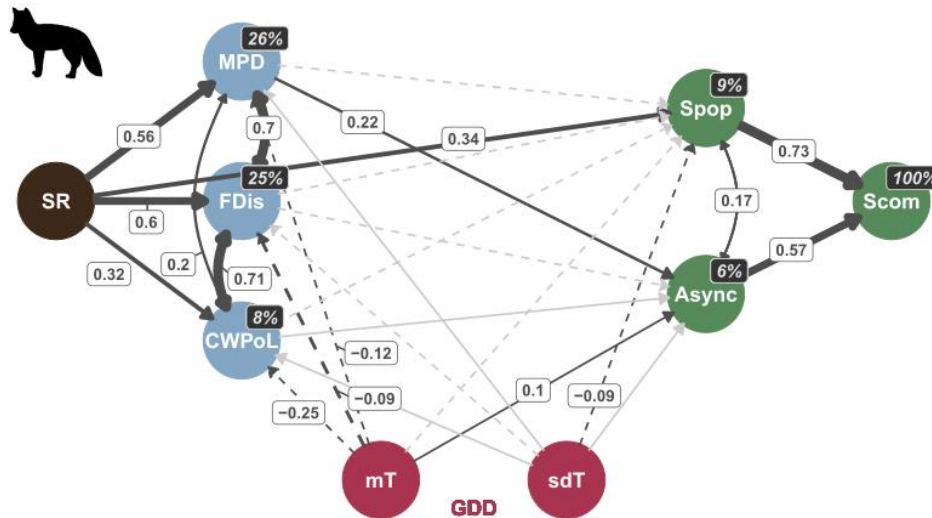


Figure S7 - Structural equation models for small mammal data using Growing Degree Days (GDD) and Freezing Degree Days (FDD) as temperature variable. Straight lines represent causal paths while curved lines represent correlation terms. Black arrows show significant effect – for which coefficients are shown in a white background box – while grey arrows show non-significant effect. Arrow width represents the effect size; solid arrows represent a positive effect and dashed arrows show a negative effect. Boxes with black background show the R^2 (%) for each response variable in the model. Coloured circles follow the standard model components where black refers to species richness, blue to traits, red to environment and green to ecosystem function. SR = species richness, FDis = functional dispersion, MPD = mean phylogenetic distance, CWPoL = community weighted pace-of-life, mT = temporal mean of temperature, sdT = temporal standard deviation of temperature, FDD = freezing degree days, GDD = growing degree days, S_{pop} = weighted average population stability, Async = asynchrony, S_{com} = community stability.

Large Mammals (GDD)

Fischer's C = 9.558; df = 14; p-value = 0.794
 Chi-square = 3.25; df = 7; p-value = 0.861
 AICc = -61409.744



Large Mammals (FDD)

Fischer's C = 10.85; df = 14; p-value = 0.698
 Chi-square = 2.554; df = 7; p-value = 0.923
 AICc = -61384.469

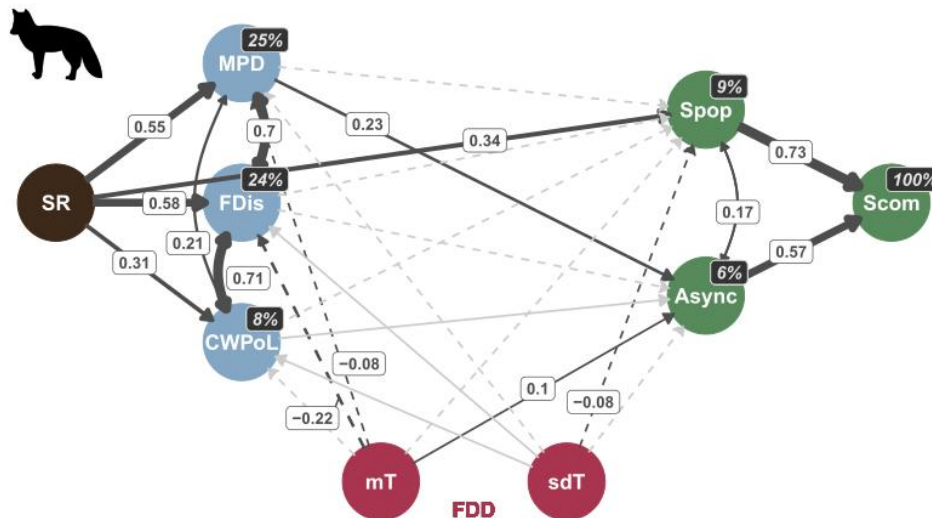


Figure S8 - Structural equation models for large mammal data using Growing Degree Days (GDD) and Freezing Degree Days (FDD) as temperature variable. Straight lines represent causal paths while curved lines represent correlation terms. Black arrows show significant effect – for which coefficients are shown in a white background box – while grey arrows show non-significant effect. Arrow width represents the effect size; solid arrows represent a positive effect and dashed arrows show a negative effect. Boxes with black background show the R² (%) for each response variable in the model. Coloured circles follow the standard model components where black refers to species richness, blue to traits, red to environment and green to ecosystem function. SR = species richness, FDis = functional dispersion, MPD = mean phylogenetic distance, CWPoL = community weighted pace-of-life, mT = temporal mean of temperature, sdT = temporal standard deviation of temperature, FDD = freezing degree days, GDD = growing degree days, S_{pop} = weighted average population stability, Async = asynchrony, S_{com} = community stability.

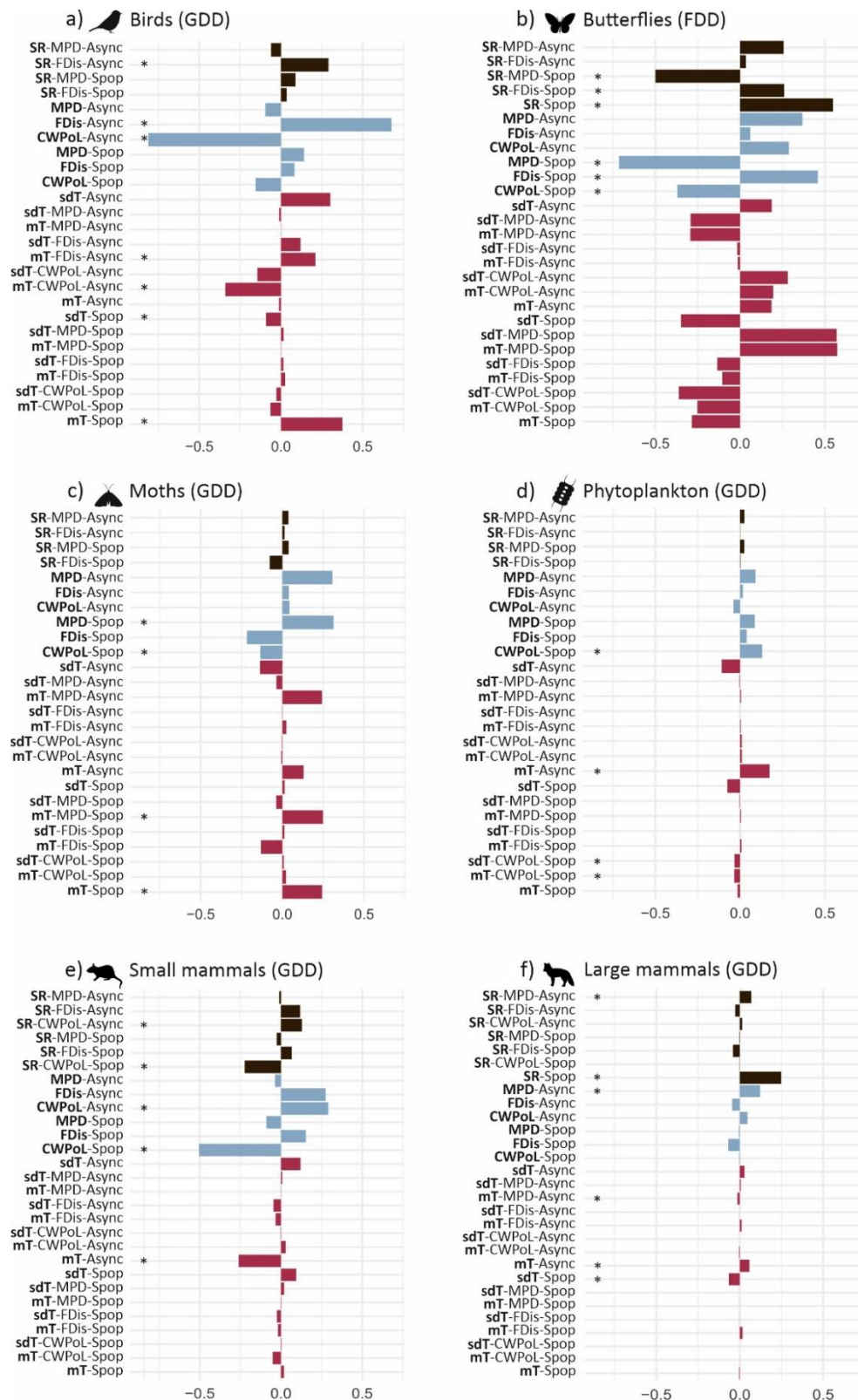


Figure S9. Indirect effects of diversity and environmental variables on community stability in the best fit structural equation model for each taxon. Indirect effects are calculated for each path in a model and plots show both statistically significant (marked with asterisk) and insignificant paths. SR = species richness, FDis = functional dispersion, MPD = mean phylogenetic distance, CWPoL = community weighted pace of life, mT = temporal mean of temperature, sdT = temporal standard deviation of temperature, FDD = freezing degree days, GDD = growing degree days, S_{pop} = weighted average population stability, Async = asynchrony