In Europe the fruit fly (*Drosophila subovscura*) has long been known to display a "cline", that is a trend of increasing wing size with latitude. The fly was accidentally introduced to North America around 1980. After about 10 years the flies were examined to see if a cline had developed, but no trend was found. The data below is from 20 years after introduction. In the data there are 11 locations in western NA and 10 sites in Europe. Is there now a cline for NS, and is it the same as the cline for Europe?

In SAS PROC MIXED and PROC GLM indicator or dummy variables are prepared for any variable in the CLASS statement. Each level is recoded as a column of values of zeros and ones such that each level has its own column with values of "1" for that level and zero otherwise. The examples below are for a 2 by 2 factorial that has been treated as a one-way ANOVA ("F" and "M" are females and males for Europe and "f" and "m" are for North America) and as a 2-way ANOVA (sex and continent).

Setting up dummy variables – SAS default setups.

Original variables				As one-way ANOVA with 4 separate categories				2 x 2 factorial with interaction							
Continent	Sex	Latitude	WingSize	F	M	f	m	EU	NA	Female	Male	EUxF	EUxM	NAxF	NAxM
eu	Female	36.4	905	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	39.3	889	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	41.3	915	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	43.4	930	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	45.5	895	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	47.3	926	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	48.5	944	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	50.4	925	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	52.1	920	1	0	0	0	1	0	1	0	1	0	0	0
eu	Female	56.1	934	1	0	0	0	1	0	1	0	1	0	0	0
eu	Male	36.4	789	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	39.3	803	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	41.3	812	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	43.4	820	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	45.5	808	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	47.3	815	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	48.5	855	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	50.4	842	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	52.1	819	0	1	0	0	1	0	0	1	0	1	0	0
eu	Male	56.1	839	0	1	0	0	1	0	0	1	0	1	0	0
na	Female	35.5	901	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	37	896	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	38.6	906	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	40.7	907	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	40.9	898	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	42.4	893	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	45	913	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	46.8	915	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	48.8	927	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	49.8	924	0	0	1	0	0	1	1	0	0	0	1	0
na	Female	50.8	930	0	0	1	0	0	1	1	0	0	0	1	0
na	Male	35.5	797	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	37	806	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	38.6	812	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	40.7	807	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	40.9	818	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	42.4	809	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	45	810	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	46.8	819	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	48.8	800	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	49.8	823	0	0	0	1	0	1	0	1	0	0	0	1
na	Male	50.8	814	0	0	0	1	0	1	0	1	0	0	0	1

The first column in the X matrix is a column of ones. Indicator variables are also placed in the X matrix. If the X matrix consists of this column of ones and then the four variables under "One-way ANOVA with 4 separate categories", the intercept and the 4 columns estimate the following means: ANOVA: μ_m, $\mu_F - \mu_m$, $\mu_M - \mu_m$, $\mu_f - \mu_m$, $\mu_m - \tilde{\mu}_m$, where $\mu_m - \mu_m$ is a missing value. If a covariable (a quantitative X variable) is present in the model, these same columns estimate intercepts and intercept differences (β_{0m}, $\beta_{0F} - \beta_{0m}$, $\beta_{0M} - \beta_{0m}$, $\beta_{0f} - \beta_{0m}$, $\beta_{0m} - \beta_{0m}$). The X variable and its interactions would fit a slope and slope differences: β_{1m}, $\beta_{1F} - \beta_{1m}$, $\beta_{1M} - \beta_{1m}$, $\beta_{1f} - \beta_{1m}$, $\beta_{1m} - \beta_{1m}$. In SAS the variable fitted, by default, as the mean, intercept or slope is the one in the last alphanumeric position.

Interactions with quantitative variables.

Original variables				As one-way with 4 separate categories				2 x 2 factorial with interaction							
Continent	Sex	Latitude	WingSize	F	M	f	m	EU	NA	Female	Male	EUxF	EUxM	NAxF	NAxM
eu	Female	36.4	905	36.4	0	0	0	36.4	0	36.4	0	36.4	0	0	0
eu	Female	39.3	889	39.3	0	0	0	39.3	0	39.3	0	39.3	0	0	0
eu	Female	41.3	915	41.3	0	0	0	41.3	0	41.3	0	41.3	0	0	0
eu	Female	43.4	930	43.4	0	0	0	43.4	0	43.4	0	43.4	0	0	0
eu	Female	45.5	895	45.5	0	0	0	45.5	0	45.5	0	45.5	0	0	0
eu	Female	47.3	926	47.3	0	0	0	47.3	0	47.3	0	47.3	0	0	0
eu	Female	48.5	944	48.5	0	0	0	48.5	0	48.5	0	48.5	0	0	0
eu	Female	50.4	925	50.4	0	0	0	50.4	0	50.4	0	50.4	0	0	0
eu	Female	52.1	920	52.1	0	0	0	52.1	0	52.1	0	52.1	0	0	0
eu	Female	56.1	934	56.1	0	0	0	56.1	0	56.1	0	56.1	0	0	0
eu	Male	36.4	789	0	36.4	0	0	36.4	0	0	36.4	0	36.4	0	0
eu	Male	39.3	803	0	39.3	0	0	39.3	0	0	39.3	0	39.3	0	0
eu	Male	41.3	812	0	41.3	0	0	41.3	0	0	41.3	0	41.3	0	0
eu	Male	43.4	820	0	43.4	0	0	43.4	0	0	43.4	0	43.4	0	0
eu	Male	45.5	808	0	45.5	0	0	45.5	0	0	45.5	0	45.5	0	0
eu	Male	47.3	815	0	47.3	0	0	47.3	0	0	47.3	0	47.3	0	0
eu	Male	48.5	855	0	48.5	0	0	48.5	0	0	48.5	0	48.5	0	0
eu	Male	50.4	842	0	50.4	0	0	50.4	0	0	50.4	0	50.4	0	0
eu	Male	52.1	819	0	52.1	0	0	52.1	0	0	52.1	0	52.1	0	0
eu	Male	56.1	839	0	56.1	0	0	56.1	0	0	56.1	0	56.1	0	0
na	Female	35.5	901	0	0	35.5	0	0	35.5	35.5	0	0	0	35.5	0
na	Female	37	896	0	0	37	0	0	37	37	0	0	0	37	0
na	Female	38.6	906	0	0	38.6	0	0	38.6	38.6	0	0	0	38.6	0
na	Female	40.7	907	0	0	40.7	0	0	40.7	40.7	0	0	0	40.7	0
na	Female	40.9	898	0	0	40.9	0	0	40.9	40.9	0	0	0	40.9	0
na	Female	42.4	893	0	0	42.4	0	0	42.4	42.4	0	0	0	42.4	0
na	Female	45	913	0	0	45	0	0	45	45	0	0	0	45	0
na	Female	46.8	915	0	0	46.8	0	0	46.8	46.8	0	0	0	46.8	0
na	Female	48.8	927	0	0	48.8	0	0	48.8	48.8	0	0	0	48.8	0
na	Female	49.8	924	0	0	49.8	0	0	49.8	49.8	0	0	0	49.8	0
na	Female	50.8	930	0	0	50.8	0	0	50.8	50.8	0	0	0	50.8	0
na	Male	35.5	797	0	0	0	35.5	0	35.5	0	35.5	0	0	0	35.5
na	Male	37	806	0	0	0	37	0	37	0	37	0	0	0	37
na	Male	38.6	812	0	0	0	38.6	0	38.6	0	38.6	0	0	0	38.6
na	Male	40.7	807	0	0	0	40.7	0	40.7	0	40.7	0	0	0	40.7
na	Male	40.9	818	0	0	0	40.9	0	40.9	0	40.9	0	0	0	40.9
na	Male	42.4	809	0	0	0	42.4	0	42.4	0	42.4	0	0	0	42.4
na	Male	45	810	0	0	0	45	0	45	0	45	0	0	0	45
na	Male	46.8	819	0	0	0	46.8	0	46.8	0	46.8	0	0	0	46.8
na	Male	48.8	800	0	0	0	48.8	0	48.8	0	48.8	0	0	0	48.8
na	Male	49.8	823	0	0	0	49.8	0	49.8	0	49.8	0	0	0	49.8
na	Male	50.8	814	0	0	0	50.8	0	50.8	0	50.8	0	0	0	50.8