SUPPLEMENTARY INFORMATION

Butterfly source sites, transportation, and handling

As some of the grazed sites did not have native populations of the focal species, we collected individual butterflies from source sites and transported them to the site so that each individual was novel to the study site. Our source sites included West Rocky Prairie and Johnson Prairie, as well as (occasionally) Maynard and Mary Mallonee's farms, all of which were also study sites. In order to prevent resampling of individuals, all individuals were marked with a small dot in the center of both hindwings using a black or red fine-tipped Sharpie. Individuals, once caught, were cooled using icepacks under a towel in a cooler before handling to mark. After marking, we let individuals cool again for at least an hour during transportation before release. This method calms the butterflies but does not hurt them (Schultz 1998). All individuals were treated similarly, so detected differences in behavior were not due to handling. After observation, individual butterflies were returned to the source site within 24 hours to prevent population impacts.

While most butterfly individuals immediately started behaving normally upon release (i.e. interacting with the habitat, searching for nectar or oviposition, flying at normal speeds, etc; see Schultz 1998 for an assessment of the effects of handling using this method on individual behavior), some individuals would exhibit obvious signs of "spooking" behavior. They would fly straight up and then take large steps for several 15 second intervals, before returning to normal behavior. "Spooking" points were not recorded with a GPS and therefore were not included in the data.

Correlated random walk equations

Eqn. 1: Net Squared Displacement with non-symmetric distribution of the turning angle ($\sin \neq 0$) (Kareiva and Shigesada 1983, Turchin 1998)

$$\bar{R}_n^2 = nm_2 + 2m_1^2 \left[\frac{(\psi - \psi^2 - s^2)n - \psi}{(1-\psi)^2 + s^2} + \frac{2s^2 + \gamma(\psi^2 + s^2)^{\frac{n+1}{2}}}{[(1-\psi)^2 + s^2]^2} \right]$$

where

n	Number steps in path
$m_1 = \frac{1}{k}\sum_{i=1}^{k} l_i$	Mean step length
$m_2 = \frac{1}{k}\sum_{i=1}^{k} l_i^2$	Mean squared step length
$\psi = \frac{1}{k}\sum_{i=1}^{k} \cos\theta$	Mean cosine of the turning angle
$s = \frac{1}{k}\sum_{i=1}^{k} \sin\theta$	Mean sine of the turning angle

$$\gamma = [(1-\psi)^2 - s^2]\cos[(n+1)\alpha] - 2s[(1-\psi)\sin[(n+1)]\alpha]$$

$$\alpha = \arctan\frac{s}{\psi}$$

Eqn. 2: Diffusion rate coefficient (Turchin 1998)

$$D = \frac{\bar{R}_n^2}{4\tau}$$

where

$\tau = \sum_{i=1}^{k} flight$	Time in flight

Assumption testing and model validation

Correlated random walk assumptions

Here we show the process of correlated random walk assumption testing. We show the results with silvery blues as our primary species being used to make conclusions, though this process was performed with ochre ringlets as well, with similar results.

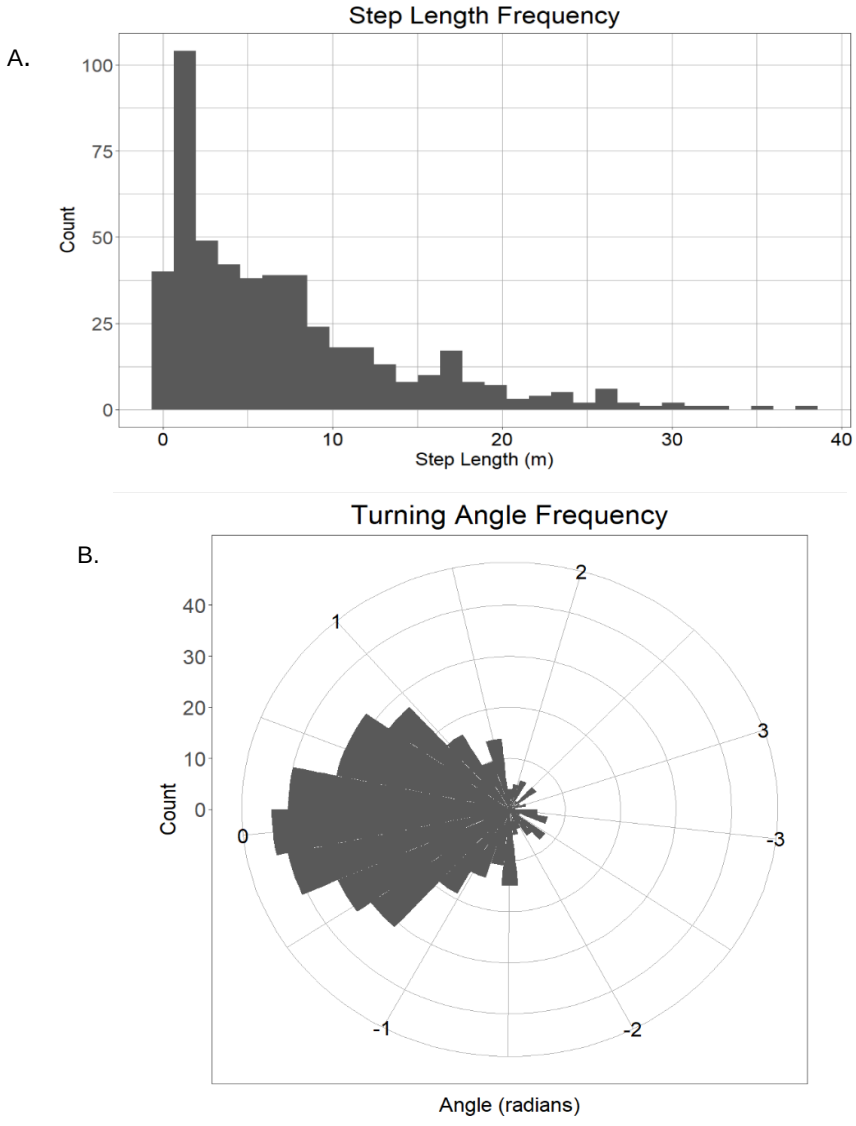

Figure 1: A. Histograms of silvery blue step lengths. B. Rose plot of turning angle frequencies

Correlated random walk models (CRW) assume that step lengths and turning angles are not serially correlated (Turchin 1998). CRW assumes that there is no correlation between the current step length and the previous one, and that the current turning angle depends only on the most recent angle. Please refer to Turchin (1998) for further information. Tests of these assumptions with silvery blues are shown below.

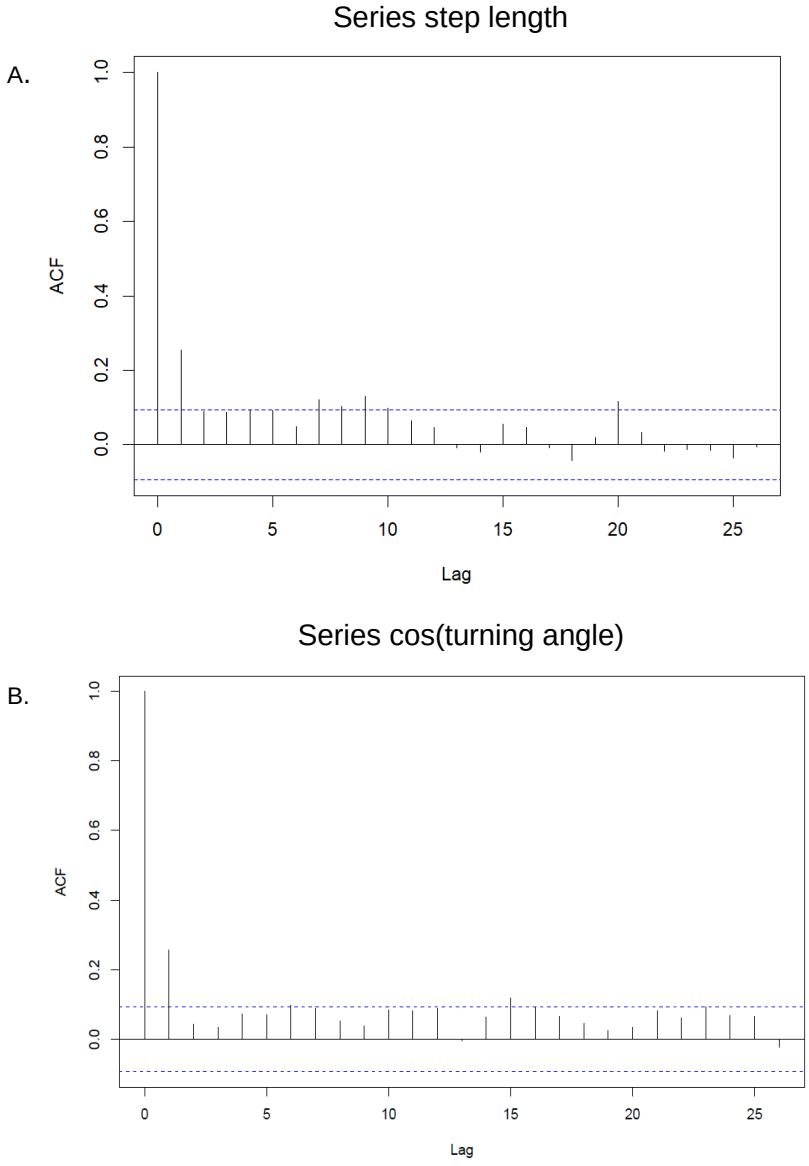

Figure 2: A. Results of the autocorrelation test for step lengths. Though this test showed that there was a lag of one step, this is a false failure of the test as all paths have been pooled between sexes and habitat types for ease of viewing. Please refer to page 136 in Turchin (1998) for further information. B. Results of the autocorrelation test for cosine of the turning angles

(testing tendency to change directions). There was a lag of one turning angle, meaning that the current angle depended on the previous one. This is consistent with CRW assumptions.

CRW models assume that net squared displacement will increase linearly with time (Turchin 1998).

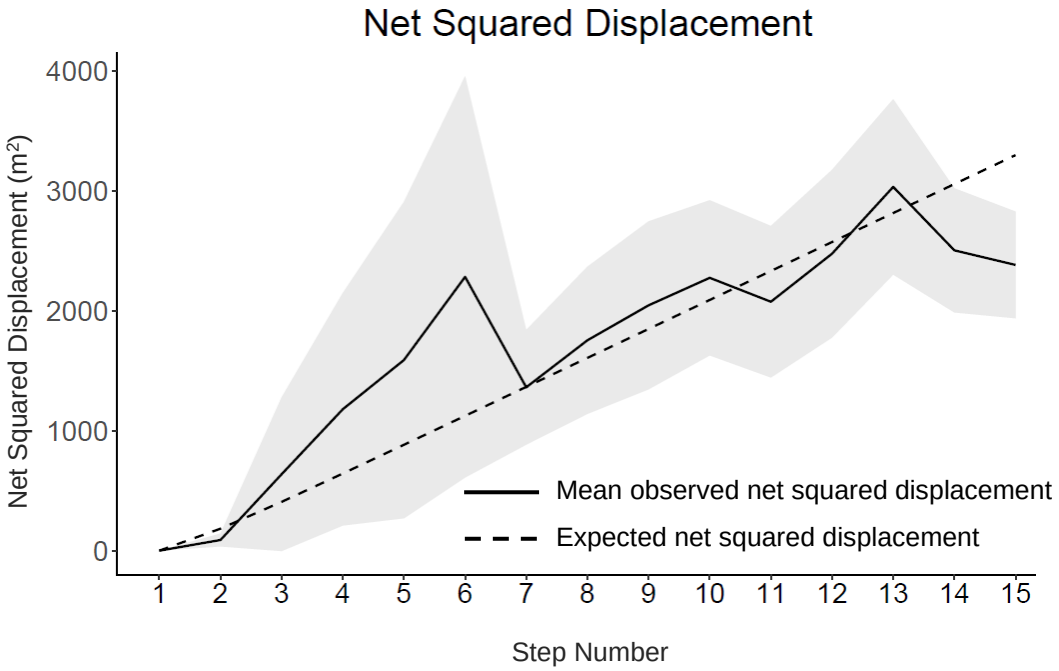

Figure 3: Observed vs expected net squared displacement through time (proxied by step number). Our results were approximately consistent with the CRW assumption that net squared displacement would increase linearly with time.

PLSR model validation

We validated our PLSR models for both species using leave-one-out cross validation (Mevik and Wehrens 2007). We evaluated statistical significance of the components based on the minimum RMSEP values calculated from the cross validation (Mevik and Wehrens 2007, Abdi 2010) and on the amount of variance explained by each component (Carrascal et al. 2009). A component may be considered significant if it explains at least five percent of the variance in the response variable.

In the silvery blue PLSR, we determined that two components were sufficient and significant because the RMSEP was minimized at two components (Figure 4). The first two components also explained at least five percent of the variance (46.65% and 7.60% respectively), while the remaining components did not. The ringlet PLSR was unable to complete LOO with scaled predictor variables, which is an indication of poor model fit and low variability within the data. Therefore, we report results only for the silvery blue PLSR.

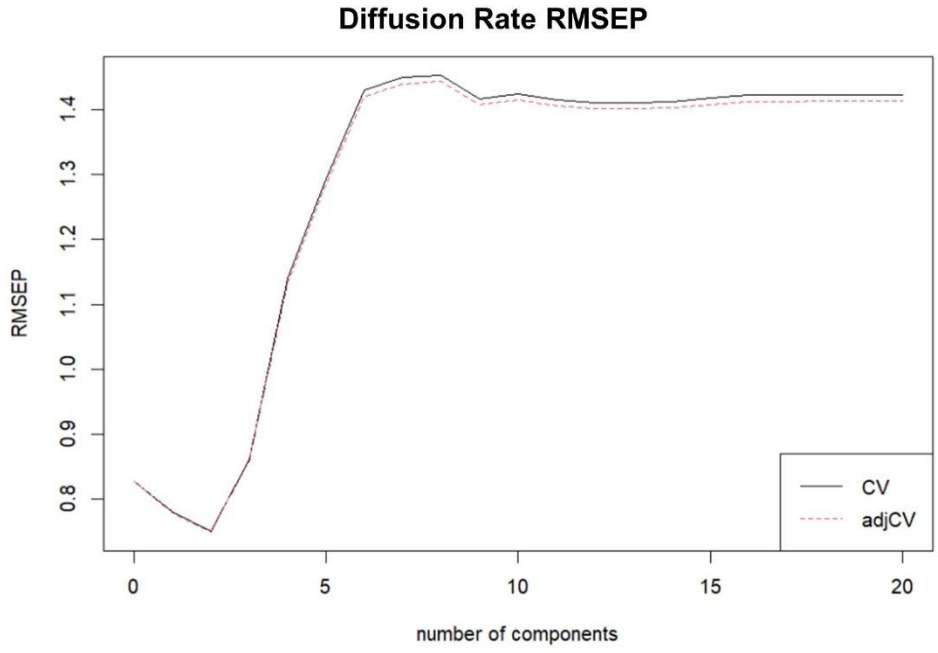

Figure 4: Root mean squared error of prediction for the silvery blue PLSR

Supplementary Results

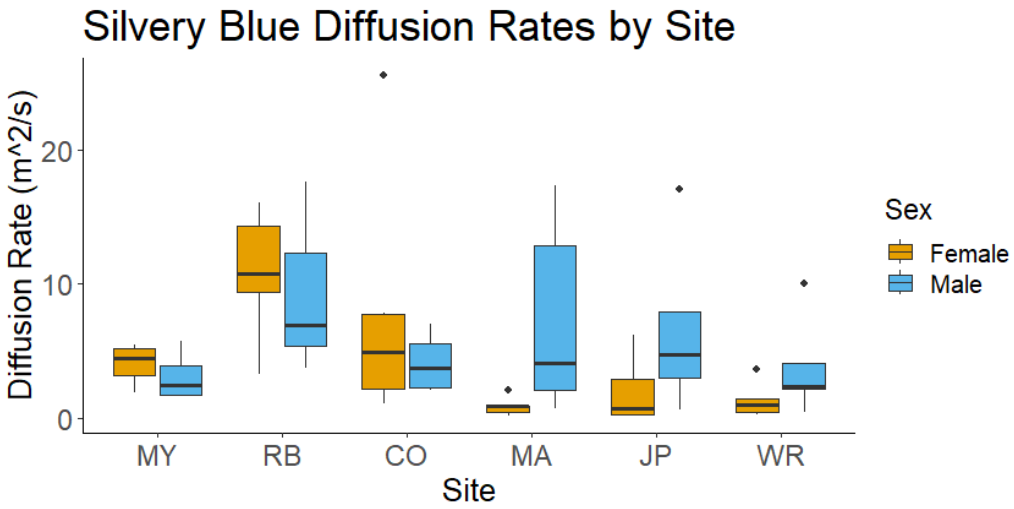

Figure 5: Boxplot of differences in silvery blue diffusion rates between sites. The sites are grouped by management type. Mary Mallonee's farm, Johnson Prairie, and West Rocky had the lowest female diffusion rates and all had large perennial *Lupinus* spp. present on site, while the other sites did not.

Table 1: Analysis of silvery blue movement parameters

	Model								
	Step Length			Turning Angle			Diffusion Rate		
Fixed Effect	d.f	*F*	*p*	d.f.	*F*	*p*	d.f.	χ^2	*p*
Management type	2.953	1.637	0.332	2.923	1.253	0.405	1	0.628	0.428
Sex	47.588	4.290	**0.044**	42.560	0.010	0.921	1	2.553	0.110
Management type X Sex	47.558	5.136	**0.010**	42.482	0.744	0.481	3	8.051	**0.050**
Random Effects	σ_{ID}	σ_{site}	σ_{resid}	σ_{ID}	σ_{site}	σ_{resid}		σ_{site}	σ_{resid}
σ	0.210	0.136	0.911	1.043	0.119	6.746		0.053	1.077
s.d.	0.455	0.368	0.954	1.022	0.345	2.597		0.229	1.038

Step length and turning angle fixed effects were assessed using F tests with Satterthwaite's method of calculating degrees of freedom. Diffusion rate fixed effects were assessed with a likelihood ratio test.

Table 2: Analysis of ochre ringlet movement parameters

	Model								
	Step Length			Turning Angle			Diffusion Rate		
Fixed Effect	d.f	*F*	*p*	d.f.	*F*	*p*	d.f.	χ^2	*p*
Management type	2.526	0.053	0.949	29.967	1.532	0.233	2	0.260	0.878
Random Effects	σ_{ID}	σ_{site}	σ_{resid}	σ_{ID}	σ_{site}	σ_{resid}		σ_{site}	σ_{resid}
σ	0.248	0.117	0.712	0.948	0.000	7.516		0.083	0.799
s.d.	0.498	0.342	0.844	0.974	0.000	2.742		0.288	0.894

Step length and turning angle fixed effects were assessed using F tests with Satterthwaite's method of calculating degrees of freedom. Diffusion rate fixed effects were assessed with a likelihood ratio test.

Table 3: A list of actively flowering plant or potential silvery blue butterfly host species found within plant plots along silvery blue butterfly paths. The category refers to how the species was classified in our analyses. If no category is listed, the species was not included in the analyses.

Species found	**Category**
Achillea millefolium	
Achmispon parviflorum	
Camassia quamash	Nectar
Castilleja hybrid sp.	
Cerastium arvense	Nectar
Collinsia grandiflora	
Collinsia parviflora	Nectar
Cytisus scoparius	
Dianthus armeria	
Draba verna	
Eriophyllum lanatum	
Fritillaria affinis	
Geranium dissectum	Nectar
Geranium molle	Nectar
Hypochaeris radicata	
Leucanthemum vulgare	Nectar
Lomatium triternatum	
Lomatium utriculatum	

Lupinus albicaulis	Nectar/Host
Lupinus bicolor	
Lupinus oreganus	Nectar/Host
Microsteris gracilis	
Myosotis discolor	
Microsteris gracilis	Nectar
Plectritis congesta	
Potentilla gracilis	
Ranunculus occidentalis	
Dodecatheon hendersonii	
Sisyrinchium idahoense	
Taraxacum officinale	
Teesdalia nudicaulis	
Trifolium dubium	
Trifolium pratensis	
Trifolium repens	Nectar
Trifolium subterraneum	Nectar
Vicia hirsuta	
Vicia sativa	Nectar/Host
Viola adunca	Nectar

Table 4: A list of actively flowering species found within plant plots along ochre ringlet paths. If nectar is listed, the species was included in our analyses. If no category is listed, the species was not included.

Species found	**Category**
Achillea millefolium	Nectar
Bellardia viscosa	
Camassia quamash	
Capsella bursa-pastoris	Nectar
Cerastium arvense	
Collinsia grandiflora	
Collinsia parviflora	
Crepis capillaris	Nectar
Cytisus scoparius	Nectar
Daucus carota	Nectar
Delphinium nuttallianum	
Geranium dissectum	
Geranium molle	
Geranium bicknellii	

Hypericum perforatum	
Hypochaeris radicata	Nectar
Leucanthemum vulgare	Nectar
Lomatium triternatum	Nectar
Lomatium utriculatum	
Lotus corniculatus	
Lupinus albicaulis	
Microsteris gracilis	
Potentilla gracilis	
Prunella vulgaris	
Ranunculus occidentalis	Nectar
Sisyrinchium idahoense	
Solidago spp.	Nectar
Symphoricarpos albus	
Teesdalia nudicaulis	
Trifolium campestre	
Trifolium dubium	
Trifolium pratensis	
Trifolium repens	Nectar
Trifolium subterraneum	
Vicia hirsuta	
Vicia sativa	
Viola adunca	