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Title page

Title

Addressing phase of population cycle and spatial scale is key to understand vole abundance in crop field margins: implications for managing a cyclic pest species

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Abstract

In simplified agricultural landscapes, some rodent species such as the common vole (*Microtus arvalis*) can reach high abundances and become agricultural pests. Crop field margins are a key structural element and, therefore, expected to play a key role in vole abundance, even within the demographic cycles that govern vole population dynamics. Here, we aim to identify i) the margin variables that determine vole population response, and ii) at which spatial scale this response can be identified and, therefore, managed. We sampled vole abundance in field margins in two replicated areas of north-western Spain during five years, including all population phases. Environmental variables related to vegetation structure, nearby crops and presence of streams or ditches were extracted at two different spatial scales: a precise small spatial scale -“trapping point” scale-, which referred to the exact location of the traps, and a broader spatial scale -“margin” scale-, that referred to the average values across the whole margin length. Using linear mixed models, we analysed the effects of the environmental variables at both spatial scales during the vole population cycle phases. The broad spatial scale accounted better for vole abundance response, being the latter dependent on the population cycle phase. The stronger effect of environmental variables consisted on vegetation structure effects during the peak phase. In this phase, margins with high cover and short vegetation promote high vole abundances, whilst margins with less cover and taller vegetation, usually associated with higher stability in margins, were related to lower peak abundances. No clear effect of nearby crops was detected in our models, when all variables were accounted for. Our results suggest that keeping stable and well vegetated field margins leads to lower abundance within crop field margins during the population outbreaks, and that any successful management strategy should be addressed to the full extent of the field margin, instead of more localized actions.

Keywords

Microtus arvalis; population ecology; agricultural landscape; agricultural intensification; vole cycle; crop management

1. Introduction

Simplified agricultural landscapes generated by intensive agriculture are hostile environments for most wildlife and they are characterized by strongly altered ecological communities, dominated by a reduced number of species favoured by the large-scale perturbation (Butet et al., 2006; Fischer et al., 2011). Some rodent species can thrive in such perturbed habitats, being among the most relevant agricultural pests around the world, and cause ecosystem disservices, such as serious crop damage, predation of beneficial invertebrates, or disease spread (Fischer et al., 2018; Stenseth et al., 2003; Tschumi et al., 2018). In the case of arable lands in Europe, the common vole (*Microtus arvalis*) is the most relevant pest vertebrate species (Jacob et al., 2014), thus we need to identify the factors that drive vole abundance to better understand, predict and manage vole outbreaks in agricultural landscapes.

In intensive agricultural landscapes, patches of semi-natural vegetation are often limited to field margins and play a crucial role as refuge habitat for rodents (Briner et al., 2005; Butet et al., 2006; de Redon et al., 2010; Rodríguez-Pastor et al., 2016). Particularly, these areas act as a refuge habitat for voles against agricultural practices that affect vegetation or soil stability and destroy vole burrows, and as a source of colonization for suboptimal habitats, such as cereal fields (Bonnet et al., 2013; Butet et al., 2006; Butet and Leroux, 2001; Rodríguez-Pastor et al., 2016; Santamaría et al., 2019). Permanent crops that are not subjected to ploughing (e.g., alfalfa *Medicago sativa*), can also maintain a spatially-dynamic large population of voles, as

they offer undisturbed soil allowing expansion and persistence of burrow systems (Heroldová et al., 2021; Rodríguez-Pastor et al., 2016; Santamaría et al., 2019).

Although most field margins are more stable habitats than crop fields, some margins may also be subjected to management actions, such as road maintenance programs that include herbicide application, mechanical removal of ground, or mowing (Meunier et al., 1999a).

Additionally, field margins may be highly variable in shape, width, and vegetation cover or height, all of them factors that could potentially affect common vole abundance and their propensity to invade adjacent crops (Briner et al., 2005; Butet et al., 2006; Renwick and Lambin, 2011; Rodríguez-Pastor et al., 2016). Thus, environmental conditions of field margins, in combination with adjacent crops, become an important driver of vole abundance, but remain poorly known. While some studies support that a high density or quality of field margins may promote crop invasion or damage (Fischer et al., 2018), others argue that wide margins with well-developed natural vegetation do not promote crop invasion (Briner et al., 2005) or might even reduce it (de Redon et al., 2010). It is therefore critical to understand the role that these different typologies and characteristics of linear habitats play in driving or modulating the vole abundance in agricultural areas.

Furthermore, even less is known about at which spatial scale these factors may determine vole presence or abundance. Studies at a local scale, find that field margins either act as sources of crop invasion (Rodríguez-Pastor et al., 2016), or on the contrary, only maintain low vole abundance, especially in the case of wooded patches or hedgerows (Delattre et al., 2009). At a landscape scale, wider and well vegetated margins seem to be associated with less pronounced outbreaks and a regulation of vole populations (de Redon et al., 2010). It has been proposed that vole response to surrounding habitat occurs at a small scale, associated with the small size of the home range of the species (Fischer et al., 2011). However, results at the microhabitat level of the sampling point might be highly variable along the temporal scale,

thus compromising the generalisation of outcomes. Additionally, from a management point of view, it would be cost-effective to target large landscape units, such as margins, if they provide consistent results. For example, vole pest management in our study area in NW Spain (Castilla y León region) has focused on large-scale burning and mechanical removal of soil and vegetation of field margins, albeit the efficacy of these methods is not known, and their negative impact on overall agricultural biodiversity is potentially high (Rodríguez-Pastor et al., 2016). Therefore, in addition to the variables affecting vole abundance in the field margins, it is paramount to define the spatial scale at which environmental conditions affect vole population dynamics.

Additionally, vole singular demography presents a further challenge in the study of the species response to the environment. Vole population dynamics are characterized by cyclic fluctuations in abundance and density, with peaks or outbreaks occurring at regular intervals every 2-5 years (Lambin et al., 2006; Luque-Larena et al., 2013; Mougeot et al., 2019). Despite this cyclic nature, vole densities at the population peak can be highly variable within or between populations of *Microtus* species (Gouveia et al., 2015; Korpela et al., 2013; Lambin et al., 2006). During low phase, when common vole density is minimal (<10 voles/ha), field margins and optimal crop habitat with stable ground (mainly alfalfa fields) act as refuges for the few voles surviving (Rodríguez-Pastor et al. 2016; Santamaría et al. 2019). During the growing phase, lasting up to four years, vole abundance increases mostly confined within these optimal habitats. At the peak phase, vole populations in optimal habitats i) reach maximal known densities over 1000 voles/ha in our study area, (see Vidal et al., 2009; more than 2000 voles/ha in central Europe, see Jacob and Tkadlec, 2010), ii) show an increase in dispersive behaviour (Domínguez, 2022), and iii) act as sources of colonization of suboptimal habitats (cereal and other crops, but also invading gardens and villages; Rodríguez-Pastor et

al., 2016). Finally, a quick population crash, usually lasting less than one year, and including spring decline, drives the population to another low phase (Mougeot et al. 2019). Understanding the factors regulating abundance of voles in field margins is of critical importance to promote effective management schemes that balance efficacy and sustainability, combining habitat management and natural biological control by predators (Crowder and Harwood, 2014; Holland et al., 2016; Paz Luna et al., 2020; Santamaría et al., 2019). In this study, we 1) analyse the environmental characteristics of the margins and identify the main drivers of vole abundance at each phase of the population cycle; and 2) we compare the responses of vole abundance to environmental factors at two spatial scales, a microhabitat or trapping point scale and broader field margin scale, to define the most relevant spatial scale to understand and manage vole population abundance across the years.

2. Methods

2.1 Study area

The study area was located in North-western Spain, Palencia province, where two study sites were selected: Boada de Campos/Capillas (*Boada* hereafter, 41° 59' N, 4° 54' O) and Revilla de Campos (*Revilla* hereafter, 41° 60' N, 4° 42' O), about 14 km apart from each other. These localities were chosen as representative of the dominant regional landscape of the area suffering the highest incidence of vole pests, and where populations reach maximal known abundances (Mougeot et al., 2019). Boada site covered an area of 6.23 km² and Revilla site covered 5.25 km² of agricultural land. The landscape in both localities is dominated by highly deforested dryland farming plains where cyclic populations of common vole reach high density peaks every 2-5 years, associated to crop damage and tularemia spread (Luque-Larena et al., 2013; Mougeot et al., 2019; Vidal et al., 2009). The climate is continental Mediterranean, with

long and cold winters and hot and dry summers. The main crops in the study area are winter cereals, mainly barley and wheat, and dryland alfalfa (Appendix A, Table A1), that conform a mixed landscape where conventional tillage and low-tilling farming methods coexist, with fallows progressively disappearing. Although both agricultural practices are present in the two study sites, low-tilling agriculture is the preferred one in Boada, while in Revilla the traditional tillage is more extended (Santamaria et al. 2019).

In this highly intensive agricultural landscape, semi-natural vegetation cover is extremely scarce and almost exclusively dominated by annual herbs and grasses in field edges and small areas of pastureland or fallows. The areas temporally more stable are field margins, fallows or uncultivated areas, and multi-annual herbaceous crops, such as alfalfa. Additionally, Boada area was included in a biological control program for common vole population management based on provisioning of 100 nest-boxes for raptors (Paz et al., 2013), while Revilla did not have any nest-boxes installed.

2.2 Data collection

We estimated vole abundance in crop field margins in the study area using Sherman live traps (LFATDG: 7.62 cm × 8.89 cm × 22.86 cm, H. B. Sherman Traps, Inc., Tallahassee, Florida, USA) for a period of 5 years (Fig. 1). The sampling design was based on a stratified random approach. We randomly selected margins in each locality, but ensuring they were distributed across all the area (Appendix B, Fig. B1), and within each margin, we randomly established five trapping points. Trapping points were at a minimum distance of 10 m from each other to avoid overlaps, and each one consisted of 10 traps, thus giving an effort of 50 traps/margin per night. All traps were unbaited and opened in the late afternoon and checked the following morning (traps were in use for an average 12-hour period) and removed after this period. To maximize trapping effectiveness, we placed traps on active burrow systems whenever present, on inactive ones if

there were not apparent active burrows, or randomly across the sampling point when no burrows were found after a systematic inspection of the margin at the trapping point. In all cases, traps were set in an area of maximum 5m radius around the coordinates of the trapping point (Appendix B, Fig. B2). Trapping sessions consisted of four consecutive days, two days in each locality. Although traps were only used during one night, two days were required to cover all the margins in each locality, thus sampling half the margins in the first day, and the remaining half the second day. Sampling effort was similar in the two study sites, with a total of 3,200-3,700 traps/night for each trapping session (average of 29.8 margins x locality x season sampled, range 16-43). We georeferenced all trapping points in the field with a GPS device.

In addition to common voles, other species were also incidentally trapped during the sampling events, including small mammals like wood mouse (*Apodemus sylvaticus*), Algerian mouse (*Mus spretus*), shrews (*Crocidula russula*), least weasel (*Mustela nivalis*), and some lizards (*Timon lepidus*) and amphibians (*Bufo bufo*). However, these additional captures did not saturate the traps, thus we did not expect them to affect the numbers of captured voles, and they were discarded for this study. Finally, abundance estimates from trapping events have been shown to be closely correlated with abundance estimates from capture-mark-recapture methods, thus being a good index of relative abundance (Jareño et al., 2014). Therefore, the number of voles captured in each trapping point (voles in 10 traps) was taken as the abundance index for further analyses.

We sampled field margins (n = 98; 54 margins in Boada, 44 margins in Revilla) eight times over the 5-year period, prioritising the same margins in subsequent visits whenever possible (55.6% of the margins were sampled in five or more occasions). The study period lasted from autumn 2013 to winter 2017 and included two vole population cycles, with very high vole abundance in the population peak of summer 2014, and medium abundance in the peak of summer 2016 (Fig.

1; Jacob et al., 2020; Mougeot et al., 2019). Abundance in the peak of 2016 was clearly smaller than in 2014, probably because population growth was limited by a persistent drought since summer 2016, aborting an expected peak with higher density in 2017 (Roos et al., 2019). Due to the small vole population size reached in spring 2015 (only 14 individuals captured in the study area), sampling was halted until summer 2016, when vole density increased again, to guarantee enough captures. After autumn 2016, vole population continuously decreased until winter 2017 (Jacob et al., 2020; Mougeot et al., 2019). Spring trapping was performed when cereal was in full growing season, summer trapping after cereal harvesting and autumn trapping usually after tilling or sowing.

We measured relevant explanatory variables in the field and through GIS data (Table 1). We classified field margins into three categories (“Margin type”): adjacent to streams or irrigation channels (*stream*), adjacent to dirt road (*ditch*), or adjacent to another field crop (*bt.crops*). At each trapping point, we measured the width of the margin (cm) and the characteristics of the vegetation (vegetation cover as percentage of area and prevalent height in cm) within the area occupied by traps. On average, margin vegetation was dominated by annual grasses, with some scarce shrubs and very rarely small trees. The average vegetation cover of the margins ranged from 31 to 72% cover, and the average vegetation height ranged from 8.5 to 45 cm (Table 2). Within localities, Boada presented an average vegetation cover of 46.8% and Revilla of 53.3% across all the study years. The average vegetation height for the localities was 20.6 and 26.1 cm, respectively.

We complemented environmental variables with publicly available annual GIS data (in raster format) for crop types provided by ItaCyL (<http://mcsncyl.itacyl.es/descarga>). We extracted crop types corresponding to the sampling year and classified them into four categories regarding their relationship with the sampled margins (“Crop type”): *alfalfa* (alfalfa crops at

both sides of the margin), *cereal* (cereal crops at both sides of the margin), *alfcer* (alfalfa in one side and cereal in the other), and *others* (any other combination, including other crops like sunflower or vetch, as well as fallows). This classification was established according to the prevalence of each crop type in the study area, where alfalfa and cereal were the main crops, and due to the differences that the various crops provide in terms of habitat, shelter and food quality for the common vole. Furthermore, we calculated the age of each alfalfa crop (the only multiannual crop in the study area) as the number of years a given field has been devoted to alfalfa production at the moment of each survey, using the annual land cover data layers from ItaCyL. A summary of the margin variables is provided in Table 2, with the full values in Appendix A, Tables A2 and A3.

Other variables such as soil characteristics or climatic variables that might influence vole populations were not considered in our analyses due to lack of variability across the study area. The two localities are located close (14 km) to each other, thus no relevant change in rainfall or temperatures is expected to occur between them. Soils are rather homogeneous with no differences among margins of the same locality, and minor ones between localities, which are already captured in our models by our variable “locality”. Therefore, we did not include a soil specific variable in our models. Additionally, we did not include a nest-box specific variable in the models for two reasons: the presence of nest boxes for prey birds in the Boada study area seemed to have a limited effect on vole populations during the study period (Fig. 1; Paz Luna et al., 2020), and if there was any possible differential predation effect between the two localities it would be also picked up by our variable “locality”.

Finally, the sampling bouts were reclassified according to phases of the vole demographic cycle (*increase, peak, decrease* and *low* phases, Fig. 1). We further checked this by assessing phase-related changes in body mass of voles (De Diego, 2017; De Diego et al., 2017), as adults in high-

density phases are 20-30% heavier than those in low-density phases (“Chitty effect”, Oli, 1999). Both in summer 2014 and 2016 we detected the appearance of the Chitty effect in our vole populations, additionally supporting that these samples corresponded to a peak phase (De Diego, 2017; De Diego et al., 2017; Jacob et al., 2020; Mougeot et al., 2019). Therefore, by evaluating demographic data and phenotypic traits, we are confident that we have correctly assigned the peak phases in our study population.

2.3 Data analysis

Since our study was designed also to investigate sanitary, genetic or anatomical traits, all captured voles were euthanized by cervical dislocation. Therefore, prior to study the effects of the environmental conditions on vole abundance, we tested whether extracting individuals from the population on a specific sampling season (captures in t) had a relevant effect on the observed captures in the same field margin the next season ($t+1$). We selected all the margins that were sampled in two consecutive seasons and analysed the effect of the extraction of individuals using a Generalized Linear Mixed Model (GLMM) for longitudinal data (Zuur et al., 2009). In this model, we used the average number of voles captured in all trapping points in a given margin in time t as a response variable, the average number of captures in time $t+1$ in the same margin and the cycle *phase* as explanatory variables, and the margin identity as a random factor, with a gaussian error distribution. Vole captures were log-transformed and model assumptions were visually checked in the residual plots. The result of this model showed lack of significant negative effects in any of the phases (Appendix A, Fig. A1). In fact, the only significant result was a positive relation between the number of captured voles in successive trappings from *increase* to *peak* phase ($\beta_{t1:peak} = 0.69 \pm 0.11$, $p < 0.001$); thus we assumed that voles extracted from the population in the previous phase did not affect negatively the number of voles captured in the next phase and proceed with further analyses.

Before running the models for environmental effects, the response variable -vole abundance index (total number of voles captured in each trapping point with 10 traps, see 2.2 data collection)- was tested for spatial autocorrelation using Moran's I. Positive autocorrelation in the values were found at distances of circa 50 m (Appendix A, Fig. A2). All continuous explanatory variables (margin width, vegetation cover, vegetation height and age of alfalfa) were tested for multicollinearity using Pearson's moment correlation and no strong correlation ($r > |0.7|$) was found (Appendix A, Fig. A3), thus all explanatory variables were included in the models.

Environmental effects on vole abundance were tested by spatially explicit GLMMs that accounted for the repeated sample structure of the sampling design and the spatial autocorrelation found in the data, at two spatial scales: trapping point and field margin. To conduct the analysis at margin scale we summarized (upscaled) all the variables measured at each trapping point (vole abundance index, width and vegetation characteristics) using the average values for each sampled margin.

The response variables in the models were i) the vole abundance index of each trapping point or ii) the average of the five trapping points for the margin scale. We tested for non-linear relationships between vole abundance index and continuous environmental variables. We found a non-linear effect of age of alfalfa crops, thus this variable was included as a quadratic term in the models.

The fixed part of the models consisted of (see variable description in Table 1):

Vole abundance ~ *alfalfa.age* + *alfalfa.age*² + *margin.type* + *crop.sides* + *phase* + *width* + *phase* x *width* + *veg.cover* + *phase* x *veg.cover* + *veg.height* + *phase* x *veg.height*.

To account for the longitudinal data and the non-independent samples, we used a nested random structure with margin identity nested in locality as random factors. Additionally, a

spherical correlation structure in the residuals was included in the models to account for spatial autocorrelation. Residuals were visually checked for model assumptions. We included variable interactions in the models to account for potential different effects of the explanatory variables during the population phases. The response variable was log-transformed and continuous explanatory variables were scaled to ensure model convergence. We decided to use the full model because we were interested in vole responses to the whole set of analysed variables, rather than obtaining a simplified model. Furthermore, the whole model will provide information on the marginal effects of the variables, i.e., the effect of one of the analysed variables keeping the others constant, that is, controlling for their effects. Nonetheless, model selection tables and effects of the top ranking model are also provided in the supplementary information for comparison purposes (Appendix C, Tables C1 and C2, Figs. C1 and C2).

All statistical analyses were done in R 3.6.1 (R Core Team, 2020). GLMMs were run using the package *nlme* (Pinheiro et al., 2019). Significance values for explanatory variables were obtained with the *Anova* function of package *car* (Fox and Weisberg, 2019), and R^2 values for the models were obtained using Nakagawa R^2 for mixed models implemented in package MuMIn (Barton, 2019).

3. Results

After removing incomplete observations, the dataset consisted of 2191 sampling points in 98 different margins, and a total of 2299 captured voles during the 5-year survey period. Vole numbers in the different cycle phases varied between the two sampled cycles, thus no reliable average value could be obtained to characterize the phases. During our sampling period, the average vole abundance index value during the low phase was 0.023 vole captures per 10 traps (i.e., trapping point, range: 0-1), during the *increase* phase was 0.576 vole captures per 10

traps (range: 0-8), during the *peak* was 2.77 (range: 0-10), and during the *decrease* phase was 0.932 (range: 0-8). We found marked differences in vole abundance index between sampling seasons, with an abundance 100-fold higher in *peak* phase than in *low* phase (Fig. 1).

Regarding the effect of environmental variables on vole abundance in margins, the model at the margin scale showed stronger responses than the model at the trapping point scale and had higher explanatory power (marginal $R^2_{\text{margins}} = 0.62$ vs marginal $R^2_{\text{points}} = 0.40$). The full model at the trapping point scale only found a significant effect of the cycle phase on vole abundance (Appendix D, Table D1 and Fig. D1). There was a clear difference in vole abundance between low and peak phases ($\beta_{\text{peak}} = 1.10 \pm 0.31$, $p = 0.024$), with medium abundances during the other two phases ($\beta_{\text{increase}} = 0.54 \pm 0.31$, $p = 0.160$; $\beta_{\text{decrease}} = 0.49 \pm 0.30$, $p = 0.189$). No other environmental effect was detected at this scale. The AICc model selection for this scale detected 10 different variable combinations within 2 AICc points of the top ranking model (Appendix C, Table C1), further highlighting the low explanatory power of variables at this scale. The top ranking model contained only the significant effects of *alfalfa age* ($\beta_{\text{alfalfa}} = 0.02 \pm 0.01$, $p < 0.001$) and the interaction *vegetation cover:phase* (F value = 3.26, df = 3, $p = 0.021$) (Appendix C, Fig. C1).

The model at the field margin scale, in addition to cycle phase, found significant interactions between cycle phases and the vegetation variables (Table 3, Fig. 2). Vegetation characteristics had different effects during the different population phases. Vegetation cover was positively related to vole abundance during the *peak* phase ($\beta_{\text{peak:veg.cover}} = 0.23 \pm 0.06$, $p < 0.001$), with no clear effects during *increase* or *decrease* phases ($\beta_{\text{increase:veg.cover}} = -0.12 \pm 0.06$, $\beta_{\text{decrease:veg.cover}} = 0.02 \pm 0.06$, $p > 0.05$ both cases). Also, a significant interaction was found for phase and vegetation height, with a negative effect of vegetation height during the *peak* phase ($\beta_{\text{peak:veg.height}} = -0.16 \pm 0.06$, $p = 0.009$), and again with no clear effects during the *increase* and *decrease* phases ($\beta_{\text{increase:veg.height}} = 0.18 \pm 0.07$, $p = 0.014$, $\beta_{\text{decrease:veg.height}} = 0.08 \pm 0.07$, $p > 0.05$).

(Fig. 2f). Regarding the remaining variables, we found no other significant effect in the full model ($p > 0.05$ in all cases). In the AICc table (Appendix C, Table C2), the models within 2 points of AICc of the top model show different combinations of the same variables included in the full model, in such a way that a model averaging process end up in the same model structure as our full model. When focusing only on the top ranking model (Appendix C, Fig. C2), this model included the effects of *crop sides* (not significant, $p > 0.05$), a significant positive effect of *alfalfa age* ($\beta_{\text{alfalfa}} = 0.06 \pm 0.03$, $p = 0.028$), and the significant interactions for *vegetation cover:phase* and *vegetation height:phase*, during the *peak* and the *increase* phases ($\beta_{\text{increase:veg.cover}} = -0.15 \pm 0.06$, $p = 0.014$, $\beta_{\text{peak:veg.cover}} = 0.24 \pm 0.06$, $p < 0.001$, $\beta_{\text{increase:veg.height}} = 0.17 \pm 0.07$, $p = 0.012$, $\beta_{\text{peak:veg.height}} = -0.16 \pm 0.05$, $p = 0.002$).

4. Discussion

In this study, we analysed vole abundance responses in different types of field margins in agricultural landscapes to identify the factors that regulate vole populations. In addition to the vole population phase, we identified two main factors modulating the vole abundance response in the study area: margin vegetation cover and height during the peak phase. Additionally, we showed the relevance of the spatial scale at which the vole responses are studied, with the spatial scale that accounted for the whole margin conditions having more clear and consistent results over the sampling period than the sampling point scale. The importance of scale in ecological studies is widely recognised. However, studies that clearly establish the adequate scale to study an ecological process are rare. Our results show that, when addressing the patterns of vole abundance in agricultural margins, the data analysed at the scale of the trapping point had clear limitations and failed to identify the patterns that only became clear at the margin scale. These results are in line with previous studies that found environmental factors at landscape scale to be major drivers of vole

populations (Delattre et al., 2009; Santamaría et al., 2019). Trapping points presented high variability over phases and seasons, as well as within the same margin or sampling bout, thus making difficult to detect consistent patterns. However, despite the high variation in abundance between trapping points, we found significant relationship between abundances detected in nearby points (as shown by the spatial autocorrelation in the data up to 50 m), that can be explained by at least two non-exclusive hypotheses. First, in linear habitats common vole may construct continuous lineal communal burrows along the margin, that can be as long as 70 m and have home ranges up to 130 m long (Brügger et al., 2010, Briner et al. 2005), thus populations sampled at points spaced 50 m or less could be exactly the same. Second, dispersal distances in female voles can be as large as 80 m, with a median distance of 49 m (Boyce and Boyce, 1988), thus the spatial correlation found could reflect typical dispersal pattern of the species, given that field margins may work as dispersal corridors (Renwick and Lambin, 2011). On the other hand, variables that accounted for the whole margin would better represent the habitat of the voles, as populations can easily move along the margin and to be affected by features depicting the full margin, thus very local variables (point scale) might fail to account for all relevant environmental conditions affecting vole abundance. Therefore, our study highlights the importance of using margin as the unit for management and research actions.

Our results show contrasting effects of vegetation cover and vegetation height on vole abundance during different phases of the population cycle. Margins with high cover and short vegetation promoted higher vole abundance during the peak phase than margins with less cover or taller vegetation. In our study area, taller vegetation at margins is usually related to more stable habitats, as it means that the margin was not disturbed –e.g., fire, mechanical management of ditches or tilling in the edge of the fields–, allowing some bushy vegetation to develop, such as brooms or hawthorns native to the study area. In contrast, recently disturbed

margins are characterized by short herbs. Voles in the less stable margins would show a
 stronger increase in abundance during the peak phase, consistently with previous studies that
 found increased abundances of the species in less stable habitats (de Redon et al., 2010;
 Meunier et al., 1999b; Rodríguez-Pastor et al., 2016). During the *increase* or *decrease* phases,
 the vegetation did not have a clear effect. We hypothesize that during these phases, vole
 population is rapidly changing, and the density-dependent spread or shrinkage of the
 population would drive the abundance patterns in the landscape rather than vegetation
 characteristics. During the *peak* phase, however, the agricultural landscape is crowded, and
 vegetation characteristics will become more relevant as they determine which margins can
 host a higher density of individuals. Margins with short and dense vegetation due to recent
 disturbances could provide more food resources and reduced predation pressure.
 The vegetation effects might be mediated by predation, but predation dynamics can be
 complex for primary consumers as the vole. For example, well vegetated field margins are the
 preferred habitat of least weasels (*Mustela nivalis*) in agricultural landscapes, which are the
 main specialist ground predator of voles in the study area (Magrini et al., 2009; Mougeot et al.,
 2020). Weasel predation has a high potential as extrinsic factor regulating microtine
 abundance and population dynamics, and can prevent vole populations to reach higher peak
 numbers in the margins (Baudrot et al., 2020; Delattre et al., 1992; Fernandez-de-Simon et al.,
 2019). On the other hand, as some aerial predators -raptors- that use low-flying hunting
 techniques, like perching or hovering, will use preferentially more open areas with shorter
 vegetation as it increases the detectability of prey (e.g., Apolloni et al., 2018; García et al.,
 2006; Toland, 1987). This would be the case for field margins, which likely hold high density of
 insects and rodents, major prey or raptors in agroecosystems (Butet et al., 2010; Meunier et
 al., 2000; Rodríguez and Bustamante, 2008). Overall, a field margin with low vegetation height
 (probably promoting lower use by weasels), but high vegetation cover (reducing hunting

success of raptors), could provide the optimal conditions for voles from a predation perspective at peak time, when most predators focus their hunting effort on overabundant voles.

The lack of clear effects of the alfalfa crops is somehow astonishing. Margins of alfalfa fields in our study area typically have high vole densities (Jareño et al., 2014), probably reflecting the high abundance of voles typical of this kind of crops, that would act as source of colonization at landscape level through the margin network. However, in our longer-term study considering alfalfa age, we did not find higher abundance of voles in margins of alfalfa fields, and only the simplified model found a positive effect of alfalfa age on vole abundance. Alfalfa crops provide stable ground where burrows persist over time, usually benefitting growth of vole populations (Jareño et al., 2015; Rodríguez-Pastor et al., 2016, Santamaría et al. 2019). Moreover, they provide high-quality preferred food (Lantová and Lanta, 2009) and good cover against aerial predators (except just after mowing, see Haim et al., 2007). For these reasons, alfalfa crops are considered the main source of voles colonizing agricultural landscapes (Rodríguez-Pastor et al., 2016; Santamaría et al., 2019) and thus, the increase in vole populations in this fields is expected to expand to their margins, in an effect similar to pastures or other fields of semi-natural herbaceous vegetation (Bonnet et al., 2013). However, we did not find a clear evidence for this effect when all environmental characteristics of the area are included in the model, i.e., controlling for effects like margin width or type. The simplified model that was able to detect this alfalfa age effect did not include margin characteristics other than vegetation structure. These results lead to two caveats that will be relevant to vole studies. First, the importance of controlling for the effects of multiple variables in the models as the effect detected in simplified models may be caused by missing variables. Second, there might be a potential interaction between margin width or type and the presence of alfalfa crops that requires further investigation to fully understand these effects.

The fact that vole population cycle phase was the main factor associated with vole abundance in field margins at both spatial scales, trapping point and field margin, was not surprising, as the different phases will be related to changes in abundance. It is interesting, however, that the difference in vole abundance between the two extremes of the cycle, the *low* and the *peak* phases, was of two orders of magnitude, and that the most recent population peak presented lower vole abundances than the second peak. Indeed, abundances at the second peak were similar to those at the first increasing phase, but still the response of vole to vegetation characteristics was associated with phase over raw abundance. This result highlights the importance of the phases as overriding forces governing the population dynamics of the species and the habitat modulating effects during peak phase. Finally, the trend in vole abundance was similar in the two localities, confirming that cyclic population dynamics are synchronous over large spatial areas of continuous similar habitat (Lambin et al., 2006; Luque-Larena et al., 2013).

Regarding the effect of the adjacent crop types, to our surprise there was no clear effect of any crop, although the model showed a tendency to lower abundances in margins between alfalfa crops, compared to cereals and, especially, other crops in the area. Cereal crops are considered suboptimal habitats for voles and are expected to increase vole density in their margins, as they force the population to seek refuge outside the crops after harvesting, contrary to the effect of alfalfa crops (Jacob, 2003; Jareño et al., 2014; Rodríguez-Pastor et al., 2016).

Although we found no significant difference in vole abundance among the different margin types, margins located between crop fields are narrower (38 ± 55 cm) than those located at ditches (196 ± 94 cm) or near streams (303 ± 146 cm). Some stream margins also presented the tallest vegetation, including some riparian vegetation and shrubs. This result highlights the importance of including the vegetation characteristics in the study, not just the type of

margins, as missing vegetation variables may lead to biased conclusions and to incorrectly identify the type of margin as the relevant variable.

5. Conclusions

Although vole population cycles are synchronized over large spatial areas driving wide temporal variation in abundance, vole populations in field margins still respond to local characteristics and, consequently, vole relative abundance might vary widely across agricultural landscape (indeed total captures in margins during peak phase ranged from 0 to 36 voles, with an average value of 14.5 voles per 100 trap-nights). In an agricultural landscape, vole outbreaks are a challenge for both managers and scientists. Our findings highlight three important aspects: first, the spatial scale that accounts for the whole margin instead of the sampling point better describes vole responses to environmental variables. Second, the responses of voles to vegetation are highly dependent of the phase of the population cycle. Lastly, the analyses of the temporal series shows that margins with well-developed vegetation are consistently related to lower vole abundance during the population outbreaks. As a general recommendation, our results suggest that any further study of the population and any population management measures should be addressed to the full extent of the margins, instead of specific areas within them. Additionally, keeping well vegetated field margins and stable systems over long time periods will result in lower local abundance, particularly in peak phase, and probably lower invasion of adjacent crops (Briner et al., 2005; de Redon et al., 2010; Rodríguez-Pastor et al., 2016). This kind of habitat management, if applied at landscape level, could probably contribute to reduce overall abundance over large areas (de Redon et al., 2010; Santamaría et al., 2019). Additionally, habitat management in margins, promoting well-vegetated margins, could enhance biological control by vole predators (Holland et al., 2016; Paz Luna et al., 2020). This could be a crucial component of any integrated, long-term and

sustainable vole rodent control strategy, acting on a key refuge habitat in agricultural landscapes. In contrast, large-scale alteration of field margin soil or vegetation by burning or mechanical removal, -the main management currently applied in field edges in our study area-, perhaps could be even counterproductive in the long-term since, since it favours less stable margins with higher vole abundance during peak phase.

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Tables

Table 1. Description of explanatory variables measured in the trapping points and n (number of trapping points for each level of the categorical variables). N total = 2194 trapping points.

Variable	Code	Description
Season	season	Season when the sampling was done (autumn13 n=316 trapping points, spring14 n=80, summer14 n=274, autumn14 n=291, spring15 n=270, summer16 n=287, autumn16 n=301, winter17 n=382)
Margin width	width	Width of the margin in cm, measured at each trapping point (range 0-800, total average 153.7)
Vegetation cover	veg.cover	Cover of vegetation at each trapping point in % (range 0-100%, total average 50.1%)
Vegetation height	veg.height	Average height of vegetation at each trapping point, in cm (range 0-200 cm, total average 21.9 cm)
Locality	locality	Locality where sampling was done (Boada n=1038 trapping points, Revilla n=1163)
Margin type	margin.type	Type of margin (stream n=525 trapping points, ditch n=741, between crops n=935)
Crops in margin sides	crop.sides	Configuration of crops in both sides of the edge (cereal n=688 trapping points: both sides have cereal crops; alfalfa n=358: both sides have alfalfa crops; alfcer n=708: there is cereal in one side and alfalfa in

the other; others n=447: any other combination of different crops).

Age of alfalfa crop	alfalfa.age	Age in years of the oldest alfalfa crop located next to the edge (range 1-8)
Population cycle	phase	Phase of the vole population cycle (increase n=396 trapping points, peak n=561, decrease n=592, low n=652)
Margin id	margin.id	Identity of each sampled margin

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Table 2. Summary of the explanatory values at the margin scale. Vegetation values are given as mean \pm sd. Vegetation cover (veg cover) is measured as percentage. Vegetation height (veg height) and margin width are measured in cm. Alfalfa age is given in years.

Locality	Season	Margin width	Margin type	Alfalfa age	Crop sides	Veg cover	Veg height
Boada	autumn13	142.0	Bt.crops	1.57	Others	72.6 \pm 26.99	14.9 \pm 13.12
Boada	autumn14	112.0	Bt.crops	1.38	Others	44.38 \pm 27.62	17.92 \pm 19.81
Boada	autumn16	145.1	Bt.crops	2.00	Cereal	32.53 \pm 18.39	20.92 \pm 21.61
Boada	spring15	146.2	Bt.crops	2.00	Others	52.08 \pm 29.08	8.47 \pm 4.59
Boada	summer14	117.2	Bt.crops	1.38	Others	45.67 \pm 27.05	23.01 \pm 30.89
Boada	summer16	100.9	Bt.crops	1.93	Others	48.29 \pm 19.38	38.43 \pm 23.29
Boada	winter17	137.2	Bt.crops	1.93	Others	31.77 \pm 20.76	20.77 \pm 18.74
Revilla	autumn13	182.9	Bt.crops	1.71	Alfalfa	74.06 \pm 25.72	15.36 \pm 12.04
Revilla	autumn14	203.9	Bt.crops	1.82	Cereal	52.02 \pm 26.82	13.99 \pm 7.06
Revilla	autumn16	203.4	Bt.crops	2.55	AlfCer	39.18 \pm 16.06	19.04 \pm 13.84
Revilla	spring14	147.8	Bt.crops	1.13	Cereal	70.44 \pm 39.95	33.75 \pm 32.26
Revilla	spring15	179.8	Ditch	2.55	AlfCer	59.66 \pm 23.94	18.1 \pm 16.09
Revilla	summer14	148.5	Bt.crops	1.93	Cereal	63 \pm 31.22	26.64 \pm 13.54
Revilla	summer16	145.5	Bt.crops	2.55	Others	41.97 \pm 14.77	45.08 \pm 22.32
Revilla	summer16	145.5	Ditch	2.55	Others	41.97 \pm 14.77	45.08 \pm 22.32
Revilla	winter17	178.8	Ditch	2.52	AlfCer	37.32 \pm 21.81	17.58 \pm 16.53

Table 3. Significance values of the explanatory variables included in the spatially explicit GLMM explaining vole abundance at the margin scale.

	Chisq	df	<i>p</i> value
crop.sides	3.69	3	0.297
phase	558.64	3	<0.001***
width	0.00	1	0.946
veg.cover	3.06	1	0.080
veg.height	2.51	1	0.113
margin.type	0.08	2	0.963
alfalfa.age	2.93	1	0.087
alfalfa.age ²	1.05	1	0.305
phase:width	2.91	3	0.405
phase:veg.cover	28.30	3	<0.001***
phase:veg.height	40.81	3	<0.001***

Figure captions

Figure 1. Total number of voles captured in field margins of each locality by sampling season. On top the vole population phase is shown: I = *increasing*, P = *peak*, D = *decreasing*, L = *low*. *Captures in Spring 2014 in Boada did not have vegetation information, thus they were not included in the statistical models.

Figure 2. Effects of environmental variables on vole abundance index at the margin scale. Solid lines (a, d, e, f) and dots (b, c) represent model fit and shaded areas and bars represent the 95% confidence intervals for continuous and categorical variables, respectively.

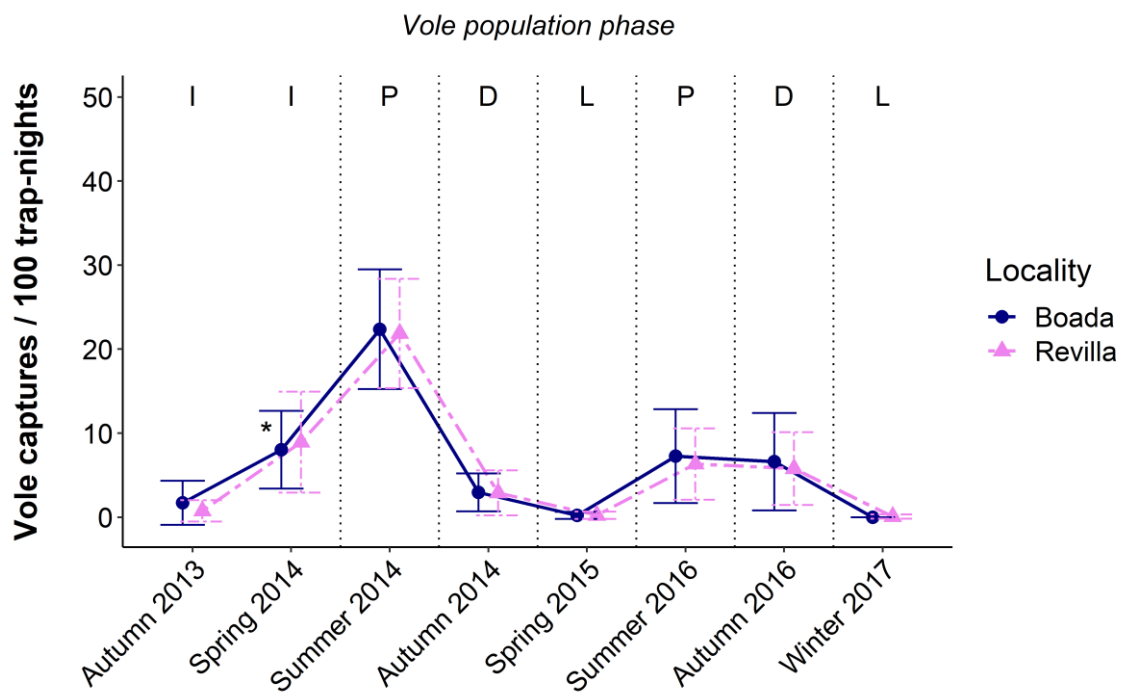


Figure 1. Average number of voles captured (\pm SD) in field margins of each locality by sampling season for an effort equivalent to 100 trap-nights. On top the vole population phase is shown: I = increasing, P = peak, D = decreasing, L = low. *Captures in Spring 2014 in Boada did not have vegetation information, thus they were not included in the statistical models.

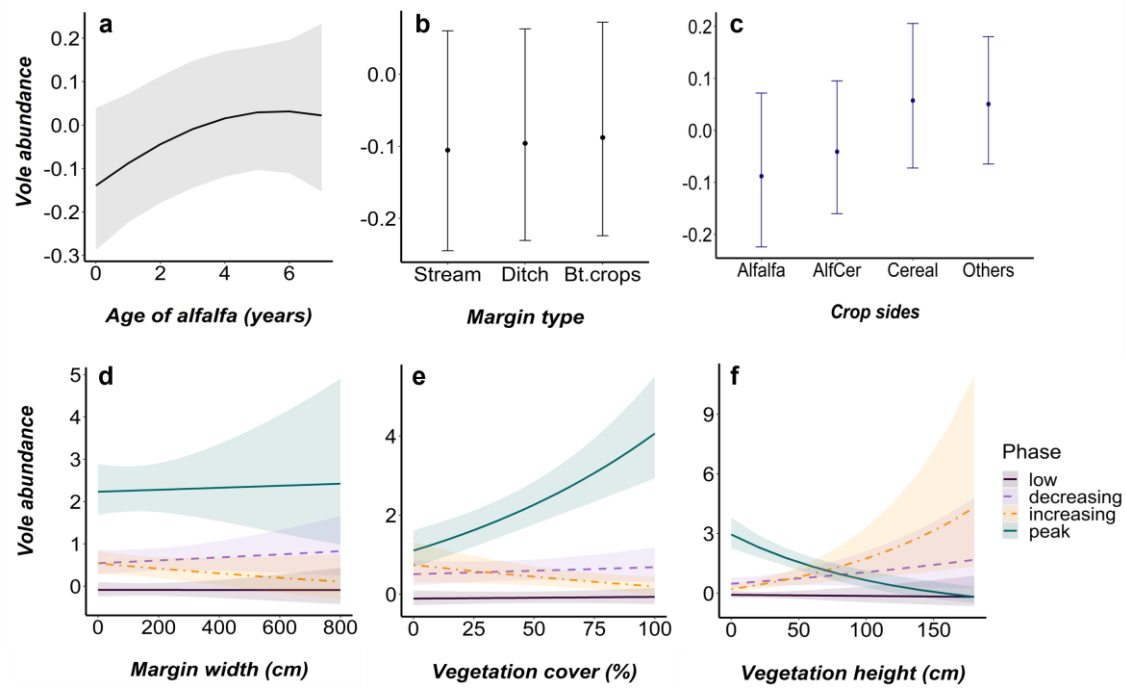


Figure 2. Effects of environmental variables on vole abundance index at the margin scale in the full model considered (see *Data analyses*). Solid lines (a, d, e, f) and dots (b, c) represent model fit and shaded areas and bars represent the 95% confidence intervals for continuous and categorical variables, respectively.

Appendix A.

Table A1. Area of the different crops present at the study sites during each year, measured in ha.

	2013	2014	2015	2016	2017	Average
BOADA						
Alfalfa	182.1	125.5	171.0	159.8	136.9	155.1
Cereal	407.3	341.4	328.9	355.6	366.8	360.0
Sunflower	11.5	151.0	98.5	80.1	66.0	81.4
Fruit trees	4.6	4.6	4.6	4.6	0.0	3.6
Others*	17.0	0.0	0.0	10.3	12.4	7.9
Bare ground	0.0	0.0	19.5	12.2	40.4	14.4
<i>TOTAL</i>	<i>622.5</i>	<i>622.5</i>	<i>622.5</i>	<i>622.5</i>	<i>622.5</i>	<i>622.5</i>
REVILLA						
Alfalfa	146.8	106.2	169.1	202.8	93.0	143.6
Cereal	293.1	334.7	345.0	249.5	338.3	312.1
Sunflower	43.7	43.5	0.0	70.0	6.0	32.6
Fruit trees	0.0	0.0	0.0	0.0	0.0	0.0
Others*	41.3	40.7	0.0	2.7	48.1	26.6
Bare ground	0.0	0.0	11.0	0.0	39.5	10.1
<i>TOTAL</i>	<i>525.0</i>	<i>525.0</i>	<i>525.0</i>	<i>525.0</i>	<i>525.0</i>	<i>525.0</i>

* Crops with reduced extension and not continuous during the years: peas, beetroot, horticultural, grassland

Table A2. Values of explanatory variables of the field margins across localities and sampling seasons.

Locality	Season	Margin	Phase	Veg cover (%)	Veg height (cm)	Margin width (cm)	Margin type	Alfalfa age	Crop sides
Boada	autumn13	B01	Increasing	86	12.3	0	Bt.crops	1	AlfCer
Boada	autumn13	B02	Increasing	60	4.5	0	Bt.crops	1	AlfCer
Boada	autumn13	B03	Increasing	54	6.4	20	Bt.crops	1	AlfCer
Boada	autumn13	B04	Increasing	100	37.1	100	Ditch	1	AlfCer
Boada	autumn13	B05	Increasing	17	6.8	0	Bt.crops	3	Alfalfa
Boada	autumn13	B07	Increasing	100	20.3	370	Stream	3	Alfalfa
Boada	autumn13	B08	Increasing	100	20.8	350	Stream	3	Alfalfa
Boada	autumn13	B09	Increasing	94	17.6	50	Ditch	3	Others
Boada	autumn13	B10	Increasing	97	19.4	370	Stream	3	AlfCer
Boada	autumn13	B11	Increasing	77	5	0	Bt.crops	3	AlfCer
Boada	autumn13	B12	Increasing	19	2	0	Bt.crops	3	Others
Boada	autumn13	B13	Increasing	71	14	220	Ditch	0	Others
Boada	autumn13	B1301	Increasing	43	3.3	20	Bt.crops	3	AlfCer
Boada	autumn13	B1302	Increasing	71	32.9	270	Ditch	3	AlfCer
Boada	autumn13	B1303	Increasing	94	11.3	270	Stream	3	AlfCer
Boada	autumn13	B1304	Increasing	67	11.5	30	Bt.crops	0	Cereal
Boada	autumn13	B1305	Increasing	53	4.7	0	Bt.crops	0	Others
Boada	autumn13	B1306	Increasing	85	40.5	250	Stream	0	Others
Boada	autumn13	B14	Increasing	63	7.8	0	Bt.crops	0	Cereal
Boada	autumn13	B15	Increasing	87	6.2	20	Bt.crops	0	Cereal
Boada	autumn13	B16	Increasing	80	6	0	Bt.crops	0	Others
Boada	autumn13	B17	Increasing	100	12.4	350	Ditch	0	Others
Boada	autumn13	B18	Increasing	0	0	0	Bt.crops	3	Others
Boada	autumn13	B19	Increasing	90	23.8	180	Ditch	3	Others
Boada	autumn13	B20	Increasing	97	22.9	0	Bt.crops	3	AlfCer
Boada	autumn13	B21	Increasing	54	2.1	250	Ditch	3	AlfCer
Boada	autumn13	B22	Increasing	28	7.4	600	Stream	3	Alfalfa
Boada	autumn13	B23	Increasing	70	5.75	30	Bt.crops	3	Others
Boada	autumn13	B25	Increasing	97	40.5	150	Ditch	3	AlfCer
Boada	autumn13	B26	Increasing	100	27.5	400	Stream	0	Others
Boada	autumn13	B27	Increasing	63	4.8	0	Bt.crops	0	Cereal
Boada	autumn13	B29	Increasing	81	7.4	30	Bt.crops	0	Cereal
Boada	autumn13	B30	Increasing	94	13.8	320	Stream	0	Others
Boada	autumn13	B31	Increasing	100	55	320	Stream	0	Others
Boada	autumn13	B32b	Increasing	49	7.9	0	Bt.crops	0	Cereal
Boada	autumn14	B01	Decreasing	35	35	0	Bt.crops	2	Others
Boada	autumn14	B02	Decreasing	20	8	0	Bt.crops	2	Others
Boada	autumn14	B03	Decreasing	24	11	0	Bt.crops	2	Others
Boada	autumn14	B04	Decreasing	88	17	110	Ditch	2	Others
Boada	autumn14	B06	Decreasing	40	7	300	Ditch	0	Cereal
Boada	autumn14	B07	Decreasing	28	19	108	Stream	0	Cereal
Boada	autumn14	B08	Decreasing	32	23	120	Stream	0	Cereal
Boada	autumn14	B09	Decreasing	61	5	200	Ditch	0	Cereal

Boada	autumn14	B10b	Decreasing	83	38	300	Stream	0	Cereal
Boada	autumn14	B11	Decreasing	17	5	0	Bt.crops	0	Others
Boada	autumn14	B12	Decreasing	25	5	0	Bt.crops	0	Cereal
Boada	autumn14	B13	Decreasing	82	5	100	Ditch	0	Cereal
Boada	autumn14	B14	Decreasing	30	2	12	Bt.crops	0	Cereal
Boada	autumn14	B15	Decreasing	9	12	40	Bt.crops	0	Others
Boada	autumn14	B16	Decreasing	63	12	20	Bt.crops	0	Others
Boada	autumn14	B17	Decreasing	58	8.2	620	Ditch	0	Others
Boada	autumn14	B18	Decreasing	13	9.8	20	Bt.crops	4	AlfCer
Boada	autumn14	B19	Decreasing	34	15	0	Bt.crops	4	AlfCer
Boada	autumn14	B20	Decreasing	58	11	200	Ditch	4	Others
Boada	autumn14	B21	Decreasing	73	24	300	Ditch	4	Others
Boada	autumn14	B22	Decreasing	62	16	33	Ditch	4	Alfalfa
Boada	autumn14	B23	Decreasing	76	56	100	Stream	4	AlfCer
Boada	autumn14	B25	Decreasing	23	17	29	Bt.crops	4	Others
Boada	autumn14	B26	Decreasing	100	94	300	Stream	0	Others
Boada	autumn14	B27	Decreasing	8	9	0	Bt.crops	0	Others
Boada	autumn14	B29	Decreasing	12	2	0	Bt.crops	0	Others
Boada	autumn16	B01	Decreasing	31	12.5	19	Bt.crops	4	AlfCer
Boada	autumn16	B03	Decreasing	41.3	27.3	38	Bt.crops	4	AlfCer
Boada	autumn16	B04	Decreasing	13.2	5.3	0	Ditch	4	Others
Boada	autumn16	B06	Decreasing	6.9	2	150	Ditch	0	Cereal
Boada	autumn16	B07	Decreasing	44.5	89	388	Stream	0	Cereal
Boada	autumn16	B08	Decreasing	44.7	62.3	430	Stream	0	Cereal
Boada	autumn16	B09	Decreasing	13.9	2.4	150	Ditch	0	Cereal
Boada	autumn16	B11	Decreasing	14.5	3.8	12	Bt.crops	0	Cereal
Boada	autumn16	B12	Decreasing	3.5	5	10	Bt.crops	0	Cereal
Boada	autumn16	B13	Decreasing	44	10.5	184	Ditch	0	Cereal
Boada	autumn16	B14	Decreasing	13.6	7.5	14	Bt.crops	0	Cereal
Boada	autumn16	B15	Decreasing	44.1	30.7	56	Bt.crops	0	Others
Boada	autumn16	B16	Decreasing	31.125	11.5	43.75	Bt.crops	0	Others
Boada	autumn16	B17	Decreasing	32.5	45.3	276	Ditch	2	AlfCer
Boada	autumn16	B18	Decreasing	33.5	4.3	0	Bt.crops	6	Alfalfa
Boada	autumn16	B19	Decreasing	42.7	6.6	0	Bt.crops	6	AlfCer
Boada	autumn16	B20	Decreasing	37	21.7	166	Ditch	6	Others
Boada	autumn16	B21	Decreasing	49	18.5	77	Ditch	6	AlfCer
Boada	autumn16	B22	Decreasing	39	31.7	268	Ditch	6	AlfCer
Boada	autumn16	B23	Decreasing	50.5	28.5	400	Stream	6	AlfCer
Boada	autumn16	B25	Decreasing	4.1	3.9	26	Bt.crops	6	Others
Boada	autumn16	B26	Decreasing	49.5	61.5	350	Stream	0	Others
Boada	autumn16	B27	Decreasing	16.7	2.5	5	Bt.crops	0	Cereal
Boada	autumn16	B29	Decreasing	41	9.3	17	Bt.crops	0	Others
Boada	autumn16	B30	Decreasing	32	19	360	Stream	0	Cereal
Boada	autumn16	B31	Decreasing	64	28.5	250	Stream	0	Others
Boada	autumn16	B33	Decreasing	71	32	220	Ditch	0	Cereal
Boada	autumn16	B34	Decreasing	1.9	2.6	152	Ditch	0	Others
Boada	spring15	B01	Low	32.2	12.6	17	Bt.crops	3	AlfCer
Boada	spring15	B02	Low	9.2	4.2	72	Bt.crops	3	AlfCer

Boada	spring15	B03	Low	30	9	50	Bt.crops	3	AlfCer
Boada	spring15	B04	Low	88	5	160	Ditch	3	AlfCer
Boada	spring15	B06	Low	91	9	122	Ditch	0	Others
Boada	spring15	B07	Low	82	14	400	Stream	0	Others
Boada	spring15	B08	Low	84	6	130	Stream	0	Others
Boada	spring15	B09	Low	97	9	120	Ditch	0	Others
Boada	spring15	B10b	Low	38.5	16	400	Stream	0	Others
Boada	spring15	B13	Low	48	7.8	150	Ditch	0	Others
Boada	spring15	B14	Low	31.5	11	21.6	Bt.crops	0	Others
Boada	spring15	B15	Low	10.5	7	56	Bt.crops	0	Others
Boada	spring15	B16	Low	30	2.6	50	Bt.crops	0	Others
Boada	spring15	B17	Low	70	8	260	Ditch	1	Others
Boada	spring15	B18	Low	48	6.2	50	Bt.crops	5	Alfalfa
Boada	spring15	B19	Low	48	2	100	Bt.crops	5	AlfCer
Boada	spring15	B20	Low	46	6.2	230	Ditch	5	Alfalfa
Boada	spring15	B21	Low	70	14	260	Ditch	5	Others
Boada	spring15	B22	Low	52	16.6	200	Ditch	5	AlfCer
Boada	spring15	B23	Low	92	15	400	Stream	5	Alfalfa
Boada	spring15	B25	Low	28	4.8	60	Bt.crops	5	AlfCer
Boada	spring15	B26	Low	88	12	150	Stream	0	Cereal
Boada	spring15	B27	Low	36	5.2	50	Bt.crops	0	Cereal
Boada	spring15	B29	Low	0	0	0	Bt.crops	0	Cereal
Boada	summer14	B01	Peak	84	32	20	Bt.crops	2	Others
Boada	summer14	B02	Peak	30	19	22	Bt.crops	2	Others
Boada	summer14	B03	Peak	32	22	21	Bt.crops	2	Others
Boada	summer14	B04	Peak	72	22	108	Ditch	2	Others
Boada	summer14	B06	Peak	54	19	28	Ditch	0	Cereal
Boada	summer14	B07	Peak	58	13	130	Stream	0	Cereal
Boada	summer14	B08	Peak	87	12.8	400	Stream	0	Cereal
Boada	summer14	B09	Peak	49	14.6	127	Ditch	0	Cereal
Boada	summer14	B10b	Peak	80	13.4	380	Stream	0	Cereal
Boada	summer14	B11	Peak	32	27	0	Bt.crops	0	Others
Boada	summer14	B12	Peak	7	3	66	Bt.crops	0	Cereal
Boada	summer14	B13	Peak	50	26	290	Ditch	0	Cereal
Boada	summer14	B14	Peak	21	23	35	Bt.crops	0	Cereal
Boada	summer14	B15	Peak	20	14	54	Bt.crops	0	Others
Boada	summer14	B16	Peak	11	18	28	Bt.crops	0	Others
Boada	summer14	B17	Peak	45	6	400	Ditch	0	Others
Boada	summer14	B18	Peak	37	21	40	Ditch	4	AlfCer
Boada	summer14	B19	Peak	14	8.6	34	Ditch	4	AlfCer
Boada	summer14	B20	Peak	54	11	200	Ditch	4	Alfalfa
Boada	summer14	B21	Peak	69	19.2	54	Ditch	4	Others
Boada	summer14	B22	Peak	76	27	200	Ditch	4	Alfalfa
Boada	summer14	B23	Peak	54	24	35	Stream	4	AlfCer
Boada	summer14	B25	Peak	25	13.8	26	Bt.crops	4	Others
Boada	summer14	B26	Peak	100	170	340	Stream	0	Others
Boada	summer14	B27	Peak	2.4	2.2	0	Bt.crops	0	Others
Boada	summer14	B29	Peak	24	16.6	8	Bt.crops	0	Others

Boada	summer16	B01	Peak	62	45	37	Bt.crops	4	AlfCer
Boada	summer16	B02	Peak	35	29	30	Bt.crops	4	AlfCer
Boada	summer16	B03	Peak	49.5	60.9	72	Bt.crops	4	AlfCer
Boada	summer16	B04	Peak	57.4	16.8	117	Ditch	4	Others
Boada	summer16	B06	Peak	50.25	39.625	71.25	Ditch	0	Cereal
Boada	summer16	B07	Peak	50.625	35.625	350	Stream	0	Cereal
Boada	summer16	B08	Peak	66	27.6	74	Stream	0	Cereal
Boada	summer16	B09	Peak	43	53	131	Ditch	0	Cereal
Boada	summer16	B12	Peak	64	18	0	Bt.crops	0	Cereal
Boada	summer16	B13	Peak	24.5	32	98	Ditch	0	Cereal
Boada	summer16	B14	Peak	46.5	38	25	Bt.crops	0	Cereal
Boada	summer16	B15	Peak	47	70	96	Bt.crops	0	Others
Boada	summer16	B16	Peak	28	16.5	17	Bt.crops	0	Others
Boada	summer16	B17	Peak	47	46.5	232	Ditch	2	AlfCer
Boada	summer16	B18	Peak	56.5	20	26	Bt.crops	6	Alfalfa
Boada	summer16	B19	Peak	26.25	26.25	50	Bt.crops	6	AlfCer
Boada	summer16	B20	Peak	84	60	200	Ditch	6	Alfalfa
Boada	summer16	B21	Peak	48.9	35.7	120	Bt.crops	6	AlfCer
Boada	summer16	B22	Peak	48	51	171	Ditch	6	AlfCer
Boada	summer16	B25	Peak	9	4	26	Bt.crops	6	Others
Boada	summer16	B26	Peak	68	35	160	Stream	0	Others
Boada	summer16	B27	Peak	18.6	1.7	30	Bt.crops	0	Cereal
Boada	summer16	B29	Peak	56.5	5.4	38	Bt.crops	0	Others
Boada	summer16	B30	Peak	100	102	150	Stream	0	Cereal
Boada	summer16	B31	Peak	52.7	46.5	98	Stream	0	Others
Boada	summer16	B32b	Peak	22	20	76	Bt.crops	0	Others
Boada	summer16	B33b	Peak	46	70	176	Ditch	0	Others
Boada	summer16	B34	Peak	45	70	155	Ditch	0	Others
Boada	winter17	B01	Low	13.2	1.4	15	Bt.crops	5	Others
Boada	winter17	B02	Low	0	37.5	0	Bt.crops	5	AlfCer
Boada	winter17	B03	Low	32	15.2	24	Bt.crops	5	AlfCer
Boada	winter17	B04	Low	5	21.2	144	Ditch	5	AlfCer
Boada	winter17	B05	Low	6.7	2.7	0	Bt.crops	0	Cereal
Boada	winter17	B06	Low	19.8	4.4	126	Ditch	0	Cereal
Boada	winter17	B07	Low	43.6	54	310	Stream	0	Cereal
Boada	winter17	B08	Low	54.5	14.1	350	Stream	0	Cereal
Boada	winter17	B09	Low	38	8	140	Ditch	0	Cereal
Boada	winter17	B10	Low	45	61.5	340	Stream	3	AlfCer
Boada	winter17	B11	Low	0	0	0	Bt.crops	0	Others
Boada	winter17	B12	Low	4.8	5	0	Bt.crops	0	Others
Boada	winter17	B13	Low	9.3	38.8	162	Ditch	0	Others
Boada	winter17	B14	Low	15.08	16	30	Bt.crops	0	Others
Boada	winter17	B15	Low	27	6.4	28	Bt.crops	0	Others
Boada	winter17	B16	Low	24.5	14.9	43	Bt.crops	0	Cereal
Boada	winter17	B17	Low	33	11.5	200	Ditch	0	Cereal
Boada	winter17	B18	Low	11.2	10.3	10	Bt.crops	7	AlfCer
Boada	winter17	B19	Low	5.7	0.7	0	Bt.crops	7	Others
Boada	winter17	B20	Low	49.2	14.3	192	Ditch	7	AlfCer

Boada	winter17	B21	Low	10	23.8	90	Ditch	7	AlfCer
Boada	winter17	B22	Low	48.5	22.5	134	Ditch	7	Others
Boada	winter17	B23	Low	54	62.5	550	Stream	7	Others
Boada	winter17	B25	Low	15.2	15	0	Bt.crops	7	AlfCer
Boada	winter17	B26	Low	78.5	74.5	580	Stream	0	Others
Boada	winter17	B27	Low	24.7	27.9	0	Bt.crops	0	Others
Boada	winter17	B28	Low	11.5	1.9	0	Bt.crops	0	Cereal
Boada	winter17	B29	Low	5.9	2.4	30	Bt.crops	0	Cereal
Boada	winter17	B30	Low	47	48.5	284	Stream	0	Cereal
Boada	winter17	B32	Low	35	1	0	Bt.crops	0	Cereal
Boada	winter17	B33	Low	43	22.6	152	Ditch	0	Cereal
Boada	winter17	B34	Low	46	10	192	Ditch	0	Cereal
Boada	winter17	B35	Low	38.4	54.6	380	Ditch	0	Cereal
Boada	winter17	B36	Low	43.75	18.33333	61.66667	Bt.crops	7	AlfCer
Boada	winter17	B37	Low	21.3	32.8	33.5	Bt.crops	4	Others
Boada	winter17	B38	Low	58.33333	26.66667	198.3333	Ditch	0	Others
Boada	winter17	B39	Low	55	21	180	Ditch	0	Cereal
Boada	winter17	B40	Low	78	15	196	Ditch	0	Cereal
Boada	winter17	B41	Low	44.9	23	220	Ditch	0	Others
Boada	winter17	B42	Low	60.5	26	366	Stream	0	Others
Boada	winter17	B44	Low	48	6.6	0	Bt.crops	0	Others
Boada	winter17	B45	Low	26.3	13.4	17	Bt.crops	0	Others
Boada	winter17	B46	Low	34.7	5.4	120	Ditch	0	Others
Revilla	autumn13	R01b	Increasing	24	5.3	0	Bt.crops	3	Alfalfa
Revilla	autumn13	R02	Increasing	26	4.5	0	Bt.crops	3	Alfalfa
Revilla	autumn13	R03	Increasing	96	10.7	300	Ditch	3	Alfalfa
Revilla	autumn13	R06	Increasing	21	2.6	0	Bt.crops	3	Alfalfa
Revilla	autumn13	R07	Increasing	80	9.6	300	Stream	3	AlfCer
Revilla	autumn13	R08	Increasing	58	11.1	300	Stream	3	AlfCer
Revilla	autumn13	R09	Increasing	74	10.4	200	Ditch	3	Alfalfa
Revilla	autumn13	R11	Increasing	48	8.6	0	Bt.crops	3	Alfalfa
Revilla	autumn13	R12	Increasing	88	17.9	320	Ditch	0	Cereal
Revilla	autumn13	R13	Increasing	89	16.6	30	Bt.crops	0	Others
Revilla	autumn13	R1302	Increasing	37.5	1.875	0	Bt.crops	3	Alfalfa
Revilla	autumn13	R1303	Increasing	60	9	0	Bt.crops	3	Alfalfa
Revilla	autumn13	R1304	Increasing	90	12.6	0	Bt.crops	3	AlfCer
Revilla	autumn13	R1305	Increasing	95	23.75	130	Ditch	3	AlfCer
Revilla	autumn13	R1306	Increasing	72	4.7	0	Bt.crops	0	Cereal
Revilla	autumn13	R14	Increasing	97.5	26.25	100	Bt.crops	3	Others
Revilla	autumn13	R15	Increasing	100	18.2	800	Stream	2	Others
Revilla	autumn13	R17	Increasing	88	28.7	110	Ditch	0	Others
Revilla	autumn13	R19	Increasing	98	10.3	350	Stream	0	Others
Revilla	autumn13	R20	Increasing	60	11.8	350	Stream	0	Others
Revilla	autumn13	R21	Increasing	70	15.2	350	Ditch	0	Others
Revilla	autumn13	R22	Increasing	100	50	250	Stream	2	Alfalfa
Revilla	autumn13	R22b	Increasing	40	32.5	400	Stream	2	Alfalfa
Revilla	autumn13	R24	Increasing	100	7	100	Bt.crops	2	AlfCer
Revilla	autumn13	R25	Increasing	100	42	200	Ditch	2	AlfCer

Revilla	autumn13	R26	Increasing	68	4	0	Bt.crops	0	Cereal
Revilla	autumn13	R27	Increasing	42	3.4	30	Bt.crops	0	Cereal
Revilla	autumn13	R28	Increasing	92	3.3	250	Stream	1	AlfCer
Revilla	autumn13	R29	Increasing	84	20.1	380	Stream	1	AlfCer
Revilla	autumn13	R30	Increasing	98	21.3	220	Ditch	1	Alfalfa
Revilla	autumn13	R31	Increasing	100	33	200	Ditch	1	Others
Revilla	autumn14	R01b	Decreasing	18	9	0	Bt.crops	0	Cereal
Revilla	autumn14	R02	Decreasing	17	5	100	Bt.crops	3	AlfCer
Revilla	autumn14	R03	Decreasing	70	19	200	Ditch	4	AlfCer
Revilla	autumn14	R04	Decreasing	57	18	200	Stream	0	Cereal
Revilla	autumn14	R05	Decreasing	46	7.4	21	Bt.crops	4	Others
Revilla	autumn14	R06	Decreasing	9	2.4	68	Bt.crops	4	Alfalfa
Revilla	autumn14	R07	Decreasing	68	17	250	Stream	4	AlfCer
Revilla	autumn14	R08	Decreasing	95	21	300	Stream	4	AlfCer
Revilla	autumn14	R09	Decreasing	57	12	360	Ditch	4	AlfCer
Revilla	autumn14	R10	Decreasing	72	18	190	Ditch	0	Cereal
Revilla	autumn14	R11	Decreasing	14	7.6	50	Bt.crops	4	Alfalfa
Revilla	autumn14	R12	Decreasing	48	5	300	Bt.crops	0	Cereal
Revilla	autumn14	R13	Decreasing	36	13.4	20	Bt.crops	0	Cereal
Revilla	autumn14	R14	Decreasing	70	18	220	Bt.crops	4	AlfCer
Revilla	autumn14	R15	Decreasing	93	26	500	Stream	3	AlfCer
Revilla	autumn14	R16	Decreasing	2.4	1.6	250	Ditch	0	Cereal
Revilla	autumn14	R17	Decreasing	66.66667	7	200	Ditch	0	Cereal
Revilla	autumn14	R18	Decreasing	13	9	360	Ditch	0	Cereal
Revilla	autumn14	R19	Decreasing	64	21	370	Bt.crops	0	Cereal
Revilla	autumn14	R20	Decreasing	30	10	230	Ditch	0	Cereal
Revilla	autumn14	R21	Decreasing	53	13	340	Ditch	0	Cereal
Revilla	autumn14	R22	Decreasing	48	10	340	Stream	3	Alfalfa
Revilla	autumn14	R22b	Decreasing	42.5	18.5	475	Stream	3	Alfalfa
Revilla	autumn14	R24	Decreasing	57	16	0	Bt.crops	3	AlfCer
Revilla	autumn14	R25	Decreasing	95	23	206	Ditch	3	AlfCer
Revilla	autumn14	R26	Decreasing	10	6.2	0	Bt.crops	0	Cereal
Revilla	autumn14	R27	Decreasing	45	7	28	Bt.crops	0	Cereal
Revilla	autumn14	R28	Decreasing	84	17.6	230	Stream	2	AlfCer
Revilla	autumn14	R29	Decreasing	84	25	320	Stream	2	Others
Revilla	autumn14	R30	Decreasing	82	23	250	Ditch	2	AlfCer
Revilla	autumn14	R31	Decreasing	66	27	200	Bt.crops	2	AlfCer
Revilla	autumn14	R36	Decreasing	38	13	0	Bt.crops	2	AlfCer
Revilla	autumn14	R37	Decreasing	66	15	150	Ditch	0	Cereal
Revilla	autumn16	R01	Decreasing	51.4	22.5	178	Stream	0	Others
Revilla	autumn16	R02	Decreasing	28.1	2	0	Bt.crops	5	AlfCer
Revilla	autumn16	R03	Decreasing	39.5	8	182	Ditch	0	Cereal
Revilla	autumn16	R04	Decreasing	43.3	14.7	320	Stream	0	Cereal
Revilla	autumn16	R05	Decreasing	41.9	4.5	0	Bt.crops	0	Others
Revilla	autumn16	R06	Decreasing	31.5	6.7	7	Bt.crops	6	AlfCer
Revilla	autumn16	R07	Decreasing	50	44	294	Stream	6	AlfCer
Revilla	autumn16	R08	Decreasing	48.5	29.1	212	Stream	6	AlfCer
Revilla	autumn16	R09	Decreasing	52.1	38.2	190	Ditch	6	AlfCer

Revilla	autumn16	R10	Decreasing	63	27.2	184	Ditch	0	Cereal
Revilla	autumn16	R11	Decreasing	9.6	7.7	38	Bt.crops	6	Alfalfa
Revilla	autumn16	R12	Decreasing	53.5	18.3	170	Bt.crops	0	Cereal
Revilla	autumn16	R13	Decreasing	48.5	44.7	100	Bt.crops	2	Alfalfa
Revilla	autumn16	R14	Decreasing	32.7	5.4	50	Bt.crops	6	Alfalfa
Revilla	autumn16	R15	Decreasing	43.5	8.4	580	Stream	5	Alfalfa
Revilla	autumn16	R16	Decreasing	49.5	11	372	Ditch	2	AlfCer
Revilla	autumn16	R17	Decreasing	49	28.4	180	Ditch	2	AlfCer
Revilla	autumn16	R18	Decreasing	57.5	19.7	224	Ditch	0	Cereal
Revilla	autumn16	R19	Decreasing	47.5	12.5	320	Stream	0	Others
Revilla	autumn16	R20	Decreasing	50.5	18.8	146	Bt.crops	0	Others
Revilla	autumn16	R21	Decreasing	49.6	15.8	310	Ditch	0	Others
Revilla	autumn16	R22	Decreasing	25.5	5.5	700	Stream	5	Alfalfa
Revilla	autumn16	R23	Decreasing	6.1	13.1	374	Stream	5	Alfalfa
Revilla	autumn16	R24	Decreasing	6	8.5	15	Bt.crops	5	AlfCer
Revilla	autumn16	R25	Decreasing	53.5	49.9	220	Ditch	5	AlfCer
Revilla	autumn16	R26	Decreasing	6.2	13.4	13	Bt.crops	0	Cereal
Revilla	autumn16	R27	Decreasing	15	22.3	43	Bt.crops	0	Cereal
Revilla	autumn16	R28	Decreasing	50	55.6	212	Bt.crops	0	Cereal
Revilla	autumn16	R29	Decreasing	29	10	400	Ditch	0	Others
Revilla	autumn16	R30	Decreasing	48.4	13.2	250	Ditch	4	AlfCer
Revilla	autumn16	R31	Decreasing	49.6	19	240	Ditch	0	Others
Revilla	autumn16	R32	Decreasing	38.5	21	188	Ditch	4	Others
Revilla	autumn16	R33b	Decreasing	24.5	9.3	0	Bt.crops	4	Others
Revilla	spring14	R04	Increasing	100	50	350	Stream	0	Cereal
Revilla	spring14	R05	Increasing	90	3	25	Bt.crops	4	Others
Revilla	spring14	R10	Increasing	100	60	150	Ditch	0	Cereal
Revilla	spring14	R11	Increasing	1	1	0	Bt.crops	4	Alfalfa
Revilla	spring14	R12	Increasing	100	5	150	Ditch	0	Cereal
Revilla	spring14	R13	Increasing	50	45	20	Bt.crops	0	Cereal
Revilla	spring14	R14	Increasing	30	20	10	Bt.crops	4	AlfCer
Revilla	spring14	R15	Increasing	100	5	400	Stream	3	AlfCer
Revilla	spring14	R16	Increasing	100	60	250	Ditch	0	Cereal
Revilla	spring14	R18	Increasing	100	60	250	Ditch	0	Cereal
Revilla	spring14	R19	Increasing	100	20	300	Stream	0	Cereal
Revilla	spring14	R20	Increasing	100	85	200	Stream	0	Cereal
Revilla	spring14	R21	Increasing	100	100	200	Ditch	0	Cereal
Revilla	spring14	R24	Increasing	15	5	10	Bt.crops	3	AlfCer
Revilla	spring14	R26	Increasing	1	1	0	Bt.crops	0	Cereal
Revilla	spring14	R27	Increasing	40	20	50	Bt.crops	0	Cereal
Revilla	spring15	R01b	Low	52	5	2	Bt.crops	0	Cereal
Revilla	spring15	R02	Low	32	6.2	50	Bt.crops	4	AlfCer
Revilla	spring15	R03	Low	62	64	200	Ditch	5	AlfCer
Revilla	spring15	R04	Low	76	16.6	320	Stream	0	Cereal
Revilla	spring15	R05	Low	46	9	100	Bt.crops	5	AlfCer
Revilla	spring15	R06	Low	14	5	15	Bt.crops	5	Alfalfa
Revilla	spring15	R07	Low	94	11.2	275	Ditch	5	AlfCer
Revilla	spring15	R09	Low	79	22	170	Ditch	5	AlfCer

Revilla	spring15	R10	Low	82	16	170	Ditch	0	Cereal
Revilla	spring15	R11	Low	52	5	6	Bt.crops	5	Alfalfa
Revilla	spring15	R12	Low	33	2.2	200	Bt.crops	0	Cereal
Revilla	spring15	R13	Low	35	5.4	50	Bt.crops	1	AlfCer
Revilla	spring15	R14	Low	73	8.2	38	Bt.crops	5	AlfCer
Revilla	spring15	R15	Low	100	60	260	Stream	4	Alfalfa
Revilla	spring15	R16	Low	85	10	240	Ditch	1	Others
Revilla	spring15	R17	Low	50	10.6	100	Ditch	1	Others
Revilla	spring15	R19	Low	42	15	262	Stream	0	Cereal
Revilla	spring15	R20	Low	28.6	4.2	325	Stream	0	Cereal
Revilla	spring15	R21	Low	81	34	180	Ditch	0	Cereal
Revilla	spring15	R22	Low	100	35	350	Ditch	4	Alfalfa
Revilla	spring15	R22b	Low	86.66667	23.33333	533.3333	Ditch	4	Alfalfa
Revilla	spring15	R24	Low	38	5	0	Bt.crops	4	AlfCer
Revilla	spring15	R25	Low	80	26	200	Ditch	4	AlfCer
Revilla	spring15	R26	Low	32	5	18	Bt.crops	0	Cereal
Revilla	spring15	R27	Low	58	12	50	Bt.crops	0	Others
Revilla	spring15	R28	Low	50	22	330	Stream	3	Others
Revilla	spring15	R29	Low	43	18	370	Stream	3	AlfCer
Revilla	spring15	R30	Low	46	25	200	Ditch	3	Alfalfa
Revilla	spring15	R31	Low	80	44	200	Ditch	3	AlfCer
Revilla	summer14	R01b	Peak	0	0	0	Bt.crops	0	Cereal
Revilla	summer14	R02	Peak	32	8.6	58	Bt.crops	3	AlfCer
Revilla	summer14	R03	Peak	97	6.2	200	Ditch	4	AlfCer
Revilla	summer14	R04	Peak	100	38	320	Stream	0	Cereal
Revilla	summer14	R05	Peak	92	19	130	Bt.crops	4	Others
Revilla	summer14	R06	Peak	7	7	70	Bt.crops	4	Alfalfa
Revilla	summer14	R07	Peak	91	34	178	Stream	4	AlfCer
Revilla	summer14	R08	Peak	95	30	262.5	Stream	4	AlfCer
Revilla	summer14	R09	Peak	70	16.25	190	Ditch	4	AlfCer
Revilla	summer14	R10	Peak	82	46	136	Ditch	0	Cereal
Revilla	summer14	R11	Peak	10	7.5	15	Bt.crops	4	Alfalfa
Revilla	summer14	R12	Peak	80	17.2	260	Bt.crops	0	Cereal
Revilla	summer14	R13	Peak	64	23	98	Bt.crops	0	Cereal
Revilla	summer14	R14	Peak	42	29.2	56	Bt.crops	4	AlfCer
Revilla	summer14	R15	Peak	66	58	410	Stream	3	AlfCer
Revilla	summer14	R16	Peak	80	28	210	Ditch	0	Cereal
Revilla	summer14	R18	Peak	100	41	430	Ditch	0	Cereal
Revilla	summer14	R19	Peak	76	42	136	Stream	0	Cereal
Revilla	summer14	R20	Peak	18	20	96	Stream	0	Cereal
Revilla	summer14	R21	Peak	100	37	200	Ditch	0	Cereal
Revilla	summer14	R22	Peak	45	22.5	55	Stream	3	Alfalfa
Revilla	summer14	R22b	Peak	57.5	28.75	100	Stream	3	Alfalfa
Revilla	summer14	R24	Peak	24	32	32	Bt.crops	3	AlfCer
Revilla	summer14	R25	Peak	45	16.25	58.75	Ditch	3	Others
Revilla	summer14	R26	Peak	48	38	46	Bt.crops	0	Cereal
Revilla	summer14	R27	Peak	51	40	94	Bt.crops	0	Cereal
Revilla	summer14	R28	Peak	92.5	26.25	175	Stream	2	AlfCer

Revilla	summer14	R29	Peak	38.75	17.5	100	Stream	2	Others
Revilla	summer14	R30	Peak	95	35	237.5	Ditch	2	AlfCer
Revilla	summer14	R31	Peak	91.25	35	100	Ditch	2	AlfCer
Revilla	summer16	R01	Peak	52	44	94	Stream	0	Others
Revilla	summer16	R02	Peak	24	12.4	15	Bt.crops	5	AlfCer
Revilla	summer16	R03	Peak	40.1	49	154	Ditch	0	Cereal
Revilla	summer16	R05	Peak	16.875	7.5	20	Bt.crops	0	Others
Revilla	summer16	R06	Peak	24.5	14.3	12.8	Bt.crops	6	AlfCer
Revilla	summer16	R07	Peak	51.5	56.5	326	Stream	6	AlfCer
Revilla	summer16	R08	Peak	52	66.5	294	Stream	6	AlfCer
Revilla	summer16	R09	Peak	58.5	58	192	Ditch	6	AlfCer
Revilla	summer16	R10	Peak	48	49	164	Ditch	0	Cereal
Revilla	summer16	R11	Peak	14.6	14.6	46	Bt.crops	6	Alfalfa
Revilla	summer16	R12	Peak	51	46.5	130	Bt.crops	0	Cereal
Revilla	summer16	R13	Peak	40	38.5	162	Bt.crops	2	Alfalfa
Revilla	summer16	R14	Peak	42	50	98	Bt.crops	6	Alfalfa
Revilla	summer16	R15	Peak	50	46	104	Stream	5	Alfalfa
Revilla	summer16	R16	Peak	25	22.5	180	Ditch	2	AlfCer
Revilla	summer16	R17	Peak	44.5	38.5	176	Ditch	2	AlfCer
Revilla	summer16	R18	Peak	54	74.5	290	Ditch	0	Cereal
Revilla	summer16	R19	Peak	63	64	90	Stream	0	Others
Revilla	summer16	R20	Peak	27	31	54	Bt.crops	0	Others
Revilla	summer16	R21	Peak	50	76	238	Ditch	0	Others
Revilla	summer16	R22	Peak	37.5	62	500	Stream	5	Alfalfa
Revilla	summer16	R23	Peak	35	16.5	300	Stream	5	Alfalfa
Revilla	summer16	R25	Peak	36.5	16.5	50	Ditch	5	Others
Revilla	summer16	R26	Peak	30	48.125	42.5	Bt.crops	0	Cereal
Revilla	summer16	R27	Peak	31	48	21	Bt.crops	0	Cereal
Revilla	summer16	R28	Peak	55.83333	60	61.66667	Stream	0	Cereal
Revilla	summer16	R29	Peak	43.5	51	52	Stream	0	Others
Revilla	summer16	R30	Peak	66.1	85.5	340	Ditch	4	AlfCer
Revilla	summer16	R31	Peak	58	59	222	Ditch	0	Others
Revilla	summer16	R32	Peak	64	83	64	Ditch	4	Others
Revilla	summer16	R33b	Peak	15	8.5	16	Bt.crops	4	Others
Revilla	winter17	R01	Low	37	25	300	Stream	0	Cereal
Revilla	winter17	R02	Low	12.7	2	8	Bt.crops	6	AlfCer
Revilla	winter17	R03	Low	4.9	4	50	Ditch	0	Others
Revilla	winter17	R04	Low	58	15	350	Stream	0	Cereal
Revilla	winter17	R05	Low	54	9	30	Bt.crops	0	Cereal
Revilla	winter17	R06	Low	29.4	8.5	11	Bt.crops	7	Others
Revilla	winter17	R07	Low	32.5	8.875	300	Stream	7	AlfCer
Revilla	winter17	R08	Low	61	18	162	Stream	7	AlfCer
Revilla	winter17	R09	Low	2.6	9.1	242	Ditch	7	AlfCer
Revilla	winter17	R10	Low	3.1	11.4	250	Ditch	0	Cereal
Revilla	winter17	R11	Low	24	8.2	40	Bt.crops	7	Alfalfa
Revilla	winter17	R12	Low	65	10.5	54	Ditch	0	Others
Revilla	winter17	R13	Low	33.5	1.5	32	Bt.crops	3	AlfCer
Revilla	winter17	R14	Low	22.5	18.4	102	Bt.crops	7	AlfCer

Revilla	winter17	R15	Low	63.92857	71.28571	521.4286	Stream	6	AlfCer
Revilla	winter17	R16	Low	46.5	11.2	228	Ditch	0	Cereal
Revilla	winter17	R17	Low	35	8	180	Ditch	0	Cereal
Revilla	winter17	R18	Low	60	22.5	150	Ditch	1	AlfCer
Revilla	winter17	R19	Low	36	14	236	Stream	1	AlfCer
Revilla	winter17	R20	Low	72	37	54	Bt.crops	0	Cereal
Revilla	winter17	R21	Low	55	9	138	Ditch	0	Cereal
Revilla	winter17	R22	Low	29	70	520	Stream	6	AlfCer
Revilla	winter17	R23	Low	13.75	40	550	Stream	6	AlfCer
Revilla	winter17	R24	Low	16.5	21.05	0	Bt.crops	6	AlfCer
Revilla	winter17	R25	Low	54.7	3.7	182	Ditch	6	AlfCer
Revilla	winter17	R26	Low	23	10	7	Bt.crops	0	Cereal
Revilla	winter17	R27	Low	7	13	43	Bt.crops	0	Cereal
Revilla	winter17	R28	Low	59.5	29	158	Stream	0	Others
Revilla	winter17	R29	Low	7.2	28.5	516	Stream	0	Others
Revilla	winter17	R30	Low	46	15.5	50	Ditch	0	Others
Revilla	winter17	R31	Low	68.61111	10.77778	148.8889	Ditch	0	Others
Revilla	winter17	R34	Low	66.5	8.5	94	Bt.crops	0	Cereal
Revilla	winter17	R35	Low	31.1	7.8	194	Ditch	0	Cereal

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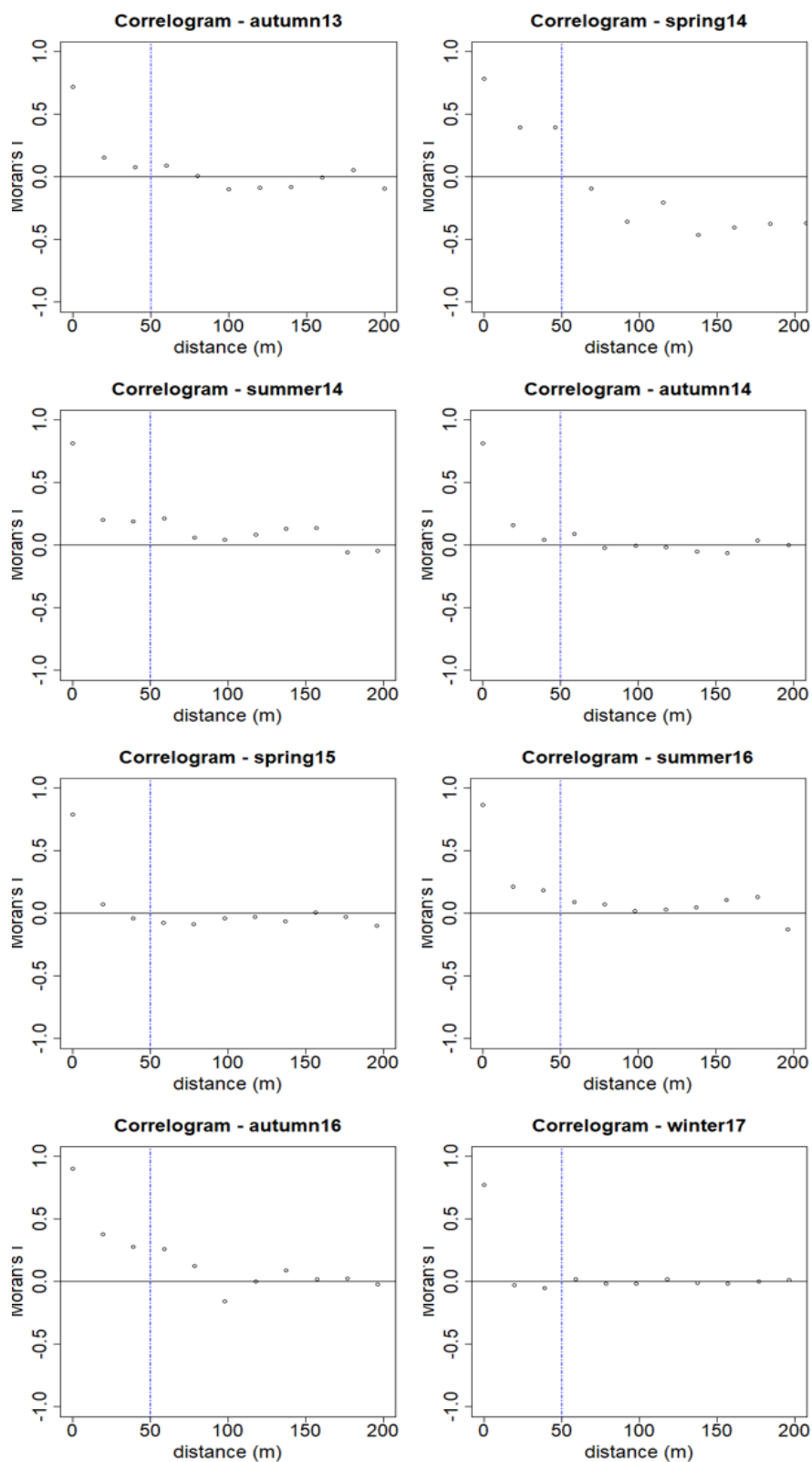


Figure A1. Moran's correlogram for each sampling season showing spatial autocorrelation in vole relative abundance. Dashed line points to a distance of 50m.

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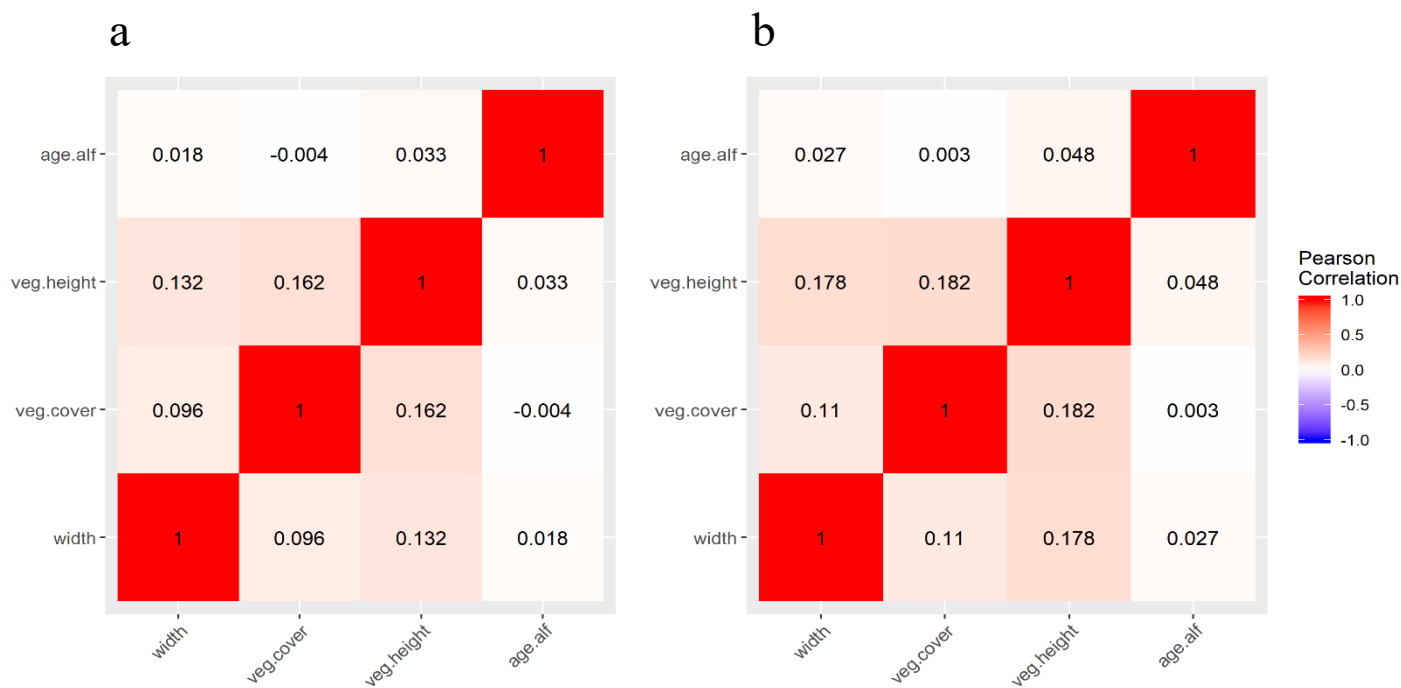


Figure A2. Correlation between environmental variables used in the analyses of vole abundance for the scale of sampling points (a) and field margins (b).

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Table A3. All combinations of crops found in the study area by locality.

Crop combination	n. Boada	n. Revilla
Alfalfa – Alfalfa	66	184
Alfalfa – Barley	199	290
Alfalfa – Forage crop	52	42
Alfalfa – Sunflower	75	34
Alfalfa – NA	37	5
Alfalfa – Other cereals (irrigated)	0	24
Alfalfa – Bare ground	17	5
Alfalfa – Wheat	33	84
Barley – Barley	201	275
Barley – Forage crop	66	36
Barley – Sunflower	89	40
Barley – Pea	5	10
Barley – NA	25	0
Barley – Other cereals	10	0
Barley – Bare ground	1	8
Barley – Wheat	48	69
Cereal – NA	9	0
Forage crop – Forage crop	15	0
Forage crop – Sunflower	5	5
Forage crop – Pea	6	0
Sunflower – Sunflower	40	25
Sunflower – Horticultural	0	5
Sunflower – NA	10	0
Sunflower – Other legumes	5	0
Sunflower – Wheat	34	0
Other cereals (irrigated) – NA	0	1
Bare ground – Barley	10	5
Wheat – Barley	23	31
Wheat – NA	12	0
Wheat – Other cereals (irrigated)	0	10
Wheat – Wheat	40	3

Appendix B – Details on survey design

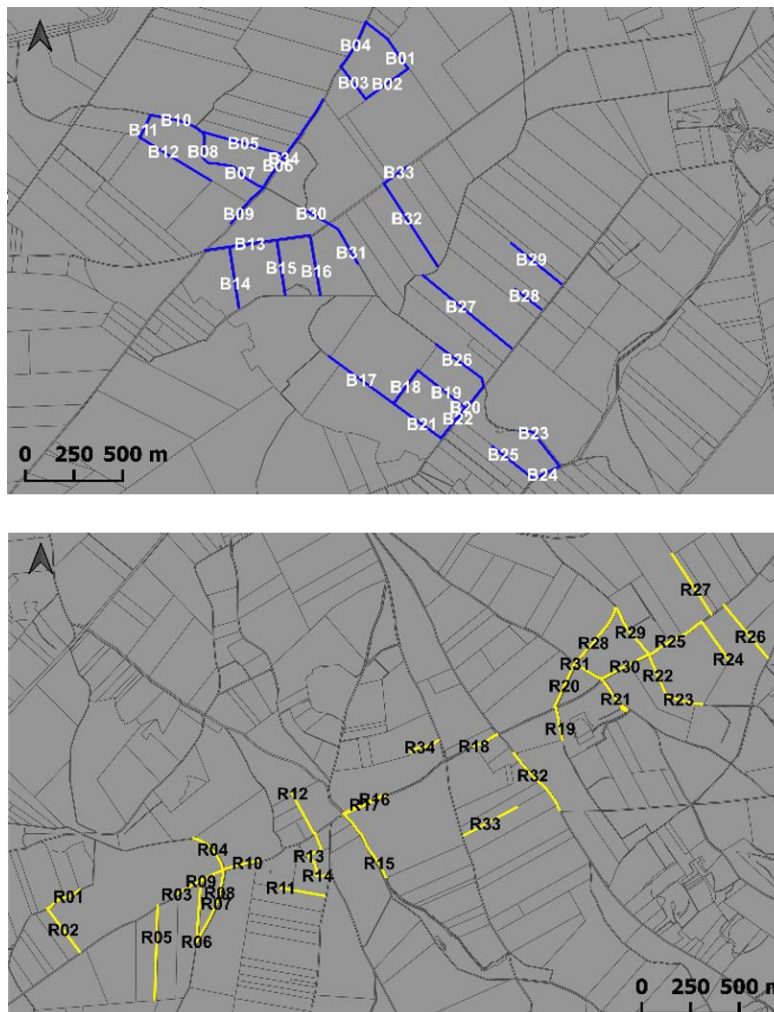


Figure B1. Field margins sampled in Boada (top panel) and Revilla (bottom panel).

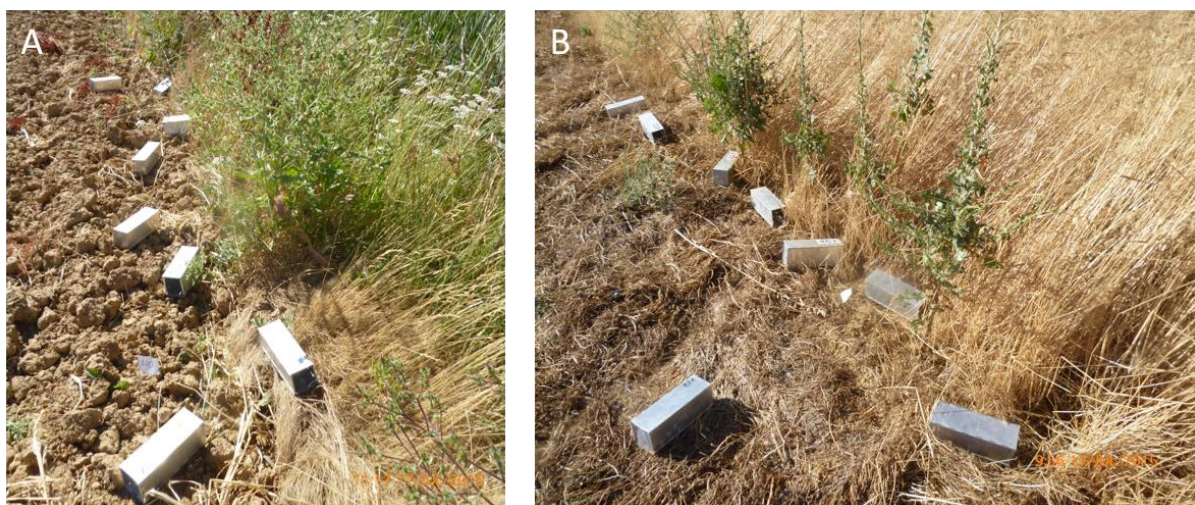


Figure B2. Detail images of the traps locations at two sampling points.

Appendix C – Model selection tables and top ranking model effects

Table C1. Model selection table at trapping point scale, including all models with AICc values within a difference of 7 points. Values in the table represent the coefficient values for numerical variables and or the inclusion (+) of the variable in the model for categorical variables. Variables included in each model are shadowed in grey. In the case of the quadratic variable, only the linear form or the combination of linear and quadratic form were allowed in the models. Interactions are only allowed when the individual variables are already in the model. AICc of the full model: 2208.272.

(Intercept)	crop sides	edge type	alfalfa age	alfalfa age^2	phase	Veg cover	Veg height	margin width	phase:veg cover	phase:veg height	phase:width	df	logLik	AICc	delta
-0.024	NA	NA	0.020	NA	+	0.000	NA	NA	+	NA	NA	15	-1082	2194.2	0
-0.010	+	NA	0.024	NA	+	-0.001	NA	NA	+	NA	NA	18	-1079.2	2194.7	0.52
-0.023	NA	NA	0.020	NA	+	0.005	NA	-0.016	+	NA	NA	16	-1081.3	2194.8	0.59
-0.002	+	NA	0.023	NA	+	0.004	NA	-0.016	+	NA	NA	19	-1078.4	2195.2	1.03
-0.020	NA	NA	0.020	NA	+	0.001	0.016	-0.020	+	NA	NA	17	-1080.6	2195.6	1.37
-0.023	NA	NA	0.020	NA	+	-0.003	0.011	NA	+	NA	NA	16	-1081.7	2195.6	1.39
0.001	+	NA	0.024	NA	+	0.000	0.016	-0.020	+	NA	NA	20	-1077.8	2195.9	1.74
-0.009	+	NA	0.024	NA	+	-0.005	0.011	NA	+	NA	NA	19	-1078.8	2196	1.86
-0.025	NA	NA	0.021	NA	+	NA	0.003	-0.014	NA	+	NA	16	-1081.9	2196.1	1.87
-0.026	NA	NA	0.021	NA	+	0.014	-0.009	NA	NA	+	NA	16	-1081.9	2196.1	1.89
-0.024	NA	NA	0.017	0.000	+	0.000	NA	NA	+	NA	NA	16	-1082	2196.2	2.01
-0.023	NA	NA	0.021	NA	+	0.019	-0.001	-0.019	NA	+	NA	17	-1081	2196.3	2.09
-0.010	+	NA	0.024	NA	+	NA	-0.004	NA	NA	+	NA	18	-1080	2196.4	2.21
-0.012	+	NA	0.026	0.000	+	-0.001	NA	NA	+	NA	NA	19	-1079.2	2196.7	2.54
-0.023	NA	NA	0.017	0.001	+	0.005	NA	-0.016	+	NA	NA	17	-1081.3	2196.8	2.6
-0.007	+	NA	0.025	NA	+	0.016	-0.009	NA	NA	+	NA	19	-1079.3	2197	2.83
-0.027	NA	NA	0.021	0.000	+	NA	-0.004	NA	NA	+	NA	16	-1082.4	2197.1	2.96
-0.003	+	NA	0.024	0.000	+	0.004	NA	-0.016	+	NA	NA	20	-1078.4	2197.3	3.06
-0.004	+	NA	0.024	NA	+	NA	0.003	-0.014	NA	+	NA	19	-1079.5	2197.4	3.17
-0.022	NA	NA	0.021	NA	+	NA	0.019	NA	NA	NA	NA	12	-1086.7	2197.5	3.35
-0.020	NA	NA	0.017	0.001	+	0.002	0.016	-0.020	+	NA	NA	18	-1080.6	2197.6	3.39
-0.022	NA	NA	0.017	0.000	+	-0.003	0.011	NA	+	NA	NA	17	-1081.7	2197.6	3.4

-0.024	NA	NA	0.021	NA	+	0.018	NA	NA	NA	NA	NA	12	-1086.8	2197.7	3.49
-0.018	NA	+	0.020	NA	+	0.002	NA	NA	+	NA	NA	17	-1081.7	2197.7	3.54
-0.026	NA	NA	0.020	NA	+	NA	NA	NA	NA	NA	NA	11	-1087.8	2197.8	3.6
-0.026	NA	NA	0.020	NA	+	0.001	-0.004	NA	+	+	NA	19	-1079.8	2197.9	3.7
-0.001	+	NA	0.026	0.000	+	0.000	0.016	-0.020	+	NA	NA	21	-1077.8	2198	3.77
-0.023	NA	NA	0.020	NA	+	0.005	0.004	-0.019	+	+	NA	20	-1078.8	2198	3.84
-0.012	+	NA	0.028	-0.001	+	-0.005	0.011	NA	+	NA	NA	20	-1078.8	2198.1	3.88
-0.025	NA	NA	0.021	0.000	+	NA	0.003	-0.014	NA	+	NA	17	-1081.9	2198.1	3.9
-0.026	NA	NA	0.021	0.000	+	0.014	-0.009	NA	NA	+	NA	17	-1081.9	2198.1	3.92
-0.001	+	+	0.023	NA	+	0.000	NA	NA	+	NA	NA	20	-1078.9	2198.2	4.01
-0.020	NA	NA	0.021	NA	+	NA	0.024	-0.015	NA	NA	NA	13	-1086	2198.3	4.07
-0.011	+	NA	0.024	NA	+	0.000	-0.003	NA	+	+	NA	22	-1076.9	2198.3	4.09
0.000	+	NA	0.024	NA	+	0.003	0.005	-0.020	+	+	NA	23	-1075.9	2198.3	4.11
-0.023	NA	NA	0.021	0.000	+	0.019	-0.001	-0.019	NA	+	NA	18	-1081	2198.3	4.12
-0.016	+	NA	0.032	-0.001	+	NA	-0.004	NA	NA	+	NA	19	-1080	2198.4	4.18
-0.022	NA	NA	0.021	NA	+	0.024	NA	-0.015	NA	NA	NA	13	-1086.1	2198.4	4.18
-0.032	NA	+	0.020	NA	+	0.003	NA	-0.019	+	NA	NA	18	-1081.1	2198.6	4.4
-0.019	NA	NA	0.021	NA	+	0.018	0.018	-0.020	NA	NA	NA	14	-1085.2	2198.7	4.49
-0.022	NA	NA	0.021	NA	+	0.013	0.014	NA	NA	NA	NA	13	-1086.3	2198.7	4.5
-0.013	NA	+	0.020	NA	+	-0.001	0.013	NA	+	NA	NA	18	-1081.3	2198.8	4.64
-0.011	+	+	0.023	NA	+	0.002	NA	-0.020	+	NA	NA	21	-1078.2	2198.9	4.73
-0.024	NA	NA	0.020	NA	+	0.002	NA	-0.008	+	NA	+	19	-1080.3	2199	4.79
-0.013	+	NA	0.031	-0.001	+	0.016	-0.009	NA	NA	+	NA	20	-1079.3	2199	4.81
-0.001	+	NA	0.029	-0.001	+	0.021	-0.001	-0.019	NA	+	NA	21	-1078.3	2199.1	4.92
-0.002	+	NA	0.024	NA	+	0.020	NA	NA	NA	NA	NA	15	-1084.5	2199.1	4.94
-0.040	NA	+	0.021	NA	+	NA	0.004	-0.020	NA	+	NA	18	-1081.4	2199.1	4.95
-0.019	NA	+	0.021	NA	+	0.016	-0.005	NA	NA	+	NA	18	-1081.4	2199.1	4.95
-0.001	+	NA	0.023	NA	+	0.001	NA	-0.009	+	NA	+	22	-1077.4	2199.2	5
-0.004	+	NA	0.024	NA	+	NA	0.020	NA	NA	NA	NA	15	-1084.5	2199.2	5.03
0.004	+	+	0.024	NA	+	-0.003	0.014	NA	+	NA	NA	21	-1078.4	2199.2	5.06
0.501	NA	NA	0.021	NA	NA	NA	0.019	NA	NA	NA	NA	9	-1090.6	2199.3	5.13

-0.009	+	NA	0.030	-0.001	+	NA	0.003	-0.014	NA	+	NA	20	-1079.5	2199.3	5.16
-0.028	NA	+	0.020	NA	+	0.000	0.016	-0.022	+	NA	NA	19	-1080.5	2199.4	5.18
-0.007	+	+	0.024	NA	+	NA	-0.001	NA	NA	+	NA	20	-1079.5	2199.4	5.23
-0.025	NA	NA	0.020	NA	+	NA	NA	-0.007	NA	NA	NA	12	-1087.7	2199.5	5.31
-0.022	NA	NA	0.023	0.000	+	NA	0.019	NA	NA	NA	NA	13	-1086.7	2199.6	5.36
0.500	NA	NA	0.021	NA	NA	0.018	NA	NA	NA	NA	NA	9	-1090.7	2199.6	5.38
0.092	+	NA	NA	NA	+	-0.004	NA	NA	+	NA	NA	17	-1082.7	2199.6	5.41
-0.007	+	+	0.024	NA	+	-0.002	0.016	-0.023	+	NA	NA	22	-1077.6	2199.6	5.43
0.503	NA	NA	0.020	NA	NA	NA	NA	NA	NA	NA	NA	8	-1091.8	2199.7	5.51
0.006	+	NA	0.023	NA	+	0.026	NA	-0.016	NA	NA	NA	16	-1083.7	2199.7	5.55
-0.018	NA	+	0.017	0.001	+	0.002	NA	NA	+	NA	NA	18	-1081.7	2199.7	5.55
-0.007	+	NA	0.023	NA	+	NA	NA	NA	NA	NA	NA	14	-1085.8	2199.8	5.57
0.098	+	NA	NA	NA	+	0.002	NA	-0.018	+	NA	NA	18	-1081.7	2199.8	5.58
-0.033	NA	+	0.021	NA	+	0.017	0.000	-0.021	NA	+	NA	19	-1080.7	2199.8	5.59
-0.026	NA	NA	0.023	0.000	+	NA	NA	NA	NA	NA	NA	12	-1087.8	2199.8	5.6
-0.021	NA	NA	0.020	NA	+	0.000	0.015	-0.013	+	NA	+	20	-1079.7	2199.8	5.62
-0.020	NA	NA	0.021	NA	+	NA	0.024	-0.017	NA	NA	+	16	-1083.8	2199.9	5.72
-0.026	NA	NA	0.017	0.001	+	0.002	-0.004	NA	+	+	NA	20	-1079.8	2199.9	5.72
0.009	+	NA	0.024	NA	+	0.020	0.019	-0.020	NA	NA	NA	17	-1082.8	2199.9	5.73
0.501	NA	NA	0.021	NA	NA	NA	0.025	-0.016	NA	NA	NA	10	-1089.9	2200	5.77
0.004	+	+	0.024	NA	+	0.018	-0.005	NA	NA	+	NA	21	-1078.8	2200	5.77
0.001	+	NA	0.023	NA	+	-0.002	0.016	-0.015	+	NA	+	23	-1076.7	2200	5.8
-0.026	NA	NA	0.021	NA	+	NA	0.000	-0.007	NA	+	+	19	-1080.8	2200	5.82
-0.022	NA	NA	0.017	0.001	+	0.005	0.004	-0.019	+	+	NA	21	-1078.8	2200.1	5.86
-0.024	NA	NA	0.021	NA	+	0.020	-0.005	-0.011	NA	+	+	20	-1079.9	2200.1	5.9
-0.019	NA	NA	0.021	NA	+	0.019	0.018	-0.020	NA	NA	+	17	-1082.9	2200.1	5.94
-0.018	+	+	0.024	NA	+	NA	0.004	-0.021	NA	+	NA	21	-1078.9	2200.2	5.97
0.500	NA	NA	0.021	NA	NA	0.024	NA	-0.016	NA	NA	NA	10	-1090.1	2200.2	6.03
-0.002	+	+	0.024	0.000	+	0.000	NA	NA	+	NA	NA	21	-1078.9	2200.2	6.05
-0.020	NA	NA	0.023	0.000	+	NA	0.024	-0.015	NA	NA	NA	14	-1086	2200.3	6.09
0.003	+	NA	0.023	NA	+	0.027	NA	-0.016	NA	NA	+	19	-1081	2200.3	6.12

-0.013	+	NA	0.028	-0.001	+	0.000	-0.004	NA	+	+	NA	23	-1076.9	2200.3	6.12
-0.001	+	NA	0.025	0.000	+	0.003	0.005	-0.020	+	+	NA	24	-1075.9	2200.3	6.15
0.499	NA	NA	0.021	NA	NA	0.018	0.019	-0.020	NA	NA	NA	11	-1089.1	2200.4	6.2
-0.022	NA	NA	0.023	0.000	+	0.024	NA	-0.015	NA	NA	NA	14	-1086.1	2200.4	6.2
-0.006	+	+	0.024	NA	+	0.019	0.000	-0.023	NA	+	NA	22	-1078	2200.4	6.24
0.500	NA	NA	0.021	NA	NA	0.013	0.014	NA	NA	NA	NA	10	-1090.2	2200.5	6.29
-0.032	NA	+	0.016	0.001	+	0.003	NA	-0.019	+	NA	NA	19	-1081.1	2200.6	6.4
0.001	+	NA	0.024	NA	+	0.022	-0.005	-0.013	NA	+	+	23	-1077	2200.6	6.4
-0.022	NA	NA	0.023	0.000	+	0.013	0.014	NA	NA	NA	NA	14	-1086.3	2200.7	6.51
0.006	+	NA	0.024	NA	+	0.021	0.018	-0.022	NA	NA	+	20	-1080.2	2200.7	6.55
0.102	+	NA	NA	NA	+	-0.001	0.014	-0.022	+	NA	NA	19	-1081.2	2200.8	6.58
-0.013	NA	+	0.017	0.001	+	-0.001	0.013	NA	+	NA	NA	19	-1081.2	2200.8	6.65
0.521	+	NA	0.024	NA	NA	NA	0.021	NA	NA	NA	NA	12	-1088.4	2200.8	6.66
0.525	+	NA	0.024	NA	NA	0.020	NA	NA	NA	NA	NA	12	-1088.4	2200.9	6.68
-0.018	NA	+	0.020	NA	+	0.002	0.000	NA	+	+	NA	21	-1079.3	2200.9	6.76
-0.001	+	NA	0.024	NA	+	NA	0.025	-0.019	NA	NA	+	19	-1081.3	2201	6.77
-0.011	+	+	0.023	0.000	+	0.002	NA	-0.020	+	NA	NA	22	-1078.2	2201	6.77
-0.025	NA	NA	0.020	NA	+	NA	NA	-0.007	NA	NA	+	15	-1085.4	2201	6.78
-0.006	+	NA	0.024	NA	+	NA	0.001	-0.009	NA	+	+	22	-1078.3	2201	6.78
-0.024	NA	NA	0.017	0.001	+	0.003	NA	-0.008	+	NA	+	20	-1080.3	2201	6.81
-0.018	NA	+	0.021	NA	+	NA	0.021	NA	NA	NA	NA	14	-1086.4	2201.1	6.87
-0.008	+	NA	0.031	-0.001	+	0.020	NA	NA	NA	NA	NA	16	-1084.4	2201.1	6.89
-0.012	+	NA	0.033	-0.001	+	NA	0.020	NA	NA	NA	NA	16	-1084.4	2201.1	6.95
-0.040	NA	+	0.019	0.000	+	NA	0.004	-0.020	NA	+	NA	19	-1081.4	2201.2	6.98
-0.019	NA	+	0.020	0.000	+	0.016	-0.005	NA	NA	+	NA	19	-1081.4	2201.2	6.99

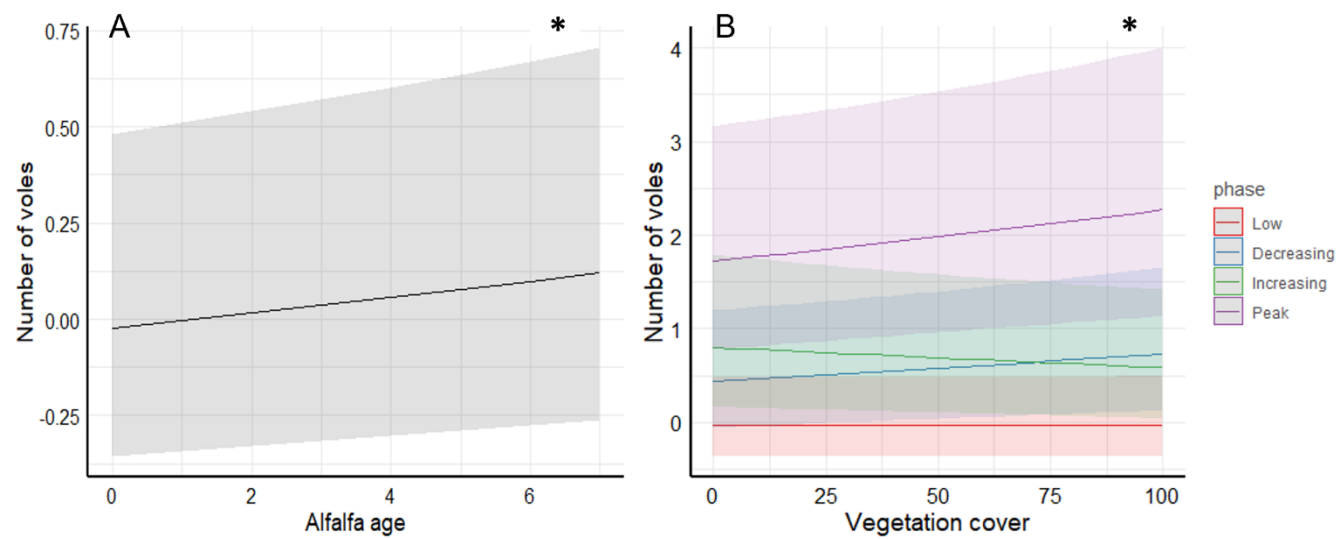


Figure C1. Summary of the model with lowest AIC value for the trapping point scale. Significant effects are highlighted by an asterisk (* $p < 0.05$).

Table C2. Model selection table at margin scale, including all models with AICc values within a difference of 7 points. Values in the table represent the coefficient values for numerical variables and or the inclusion (+) of the variable in the model for categorical variables. Variables included in each model are shadowed in grey. In the case of the quadratic variable, only the linear form or the combination of linear and quadratic form were allowed in the models. Interactions are only allowed when the individual variables are already in the model. Full model AICc: 432.971.

(Intercept)	Crop sides	Edge type	Alfalfa age	Alfalfa age^2	Phase	Veg. cover	Veg. height	Margin width	phase: veg. cover	phase: veg. height	phase: width	df	logLik	AICc	delta
-0.132	+	NA	0.029	NA	+	0.018	-0.019	NA	+	+	NA	21.000	-188.683	421.545	0.000
-0.010	NA	NA	0.020	-0.001	+	0.014	-0.005	-0.015	+	+	NA	20.000	-189.886	421.748	0.202
-0.166	+	NA	0.064	-0.006	+	0.012	-0.018	NA	+	+	NA	22.000	-188.187	422.767	1.222
0.038	NA	+	NA	NA	+	0.010	0.003	NA	+	+	NA	19.000	-191.498	422.781	1.235
-0.013	NA	NA	0.016	NA	+	0.013	-0.011	-0.008	+	+	+	22.000	-188.465	423.323	1.777
-0.123	+	NA	0.028	NA	+	0.021	-0.012	-0.011	+	+	NA	22.000	-188.557	423.507	1.962
-0.002	NA	+	0.015	NA	+	0.015	-0.004	-0.009	+	+	NA	21.000	-189.740	423.660	2.115
0.003	NA	+	0.019	-0.001	+	0.014	-0.006	NA	+	+	NA	21.000	-189.774	423.728	2.183
-0.158	+	NA	0.063	-0.005	+	0.015	-0.012	-0.009	+	+	NA	23.000	-188.096	424.808	3.262
0.033	NA	+	NA	NA	+	0.011	0.005	-0.008	+	+	NA	20.000	-191.462	424.901	3.356

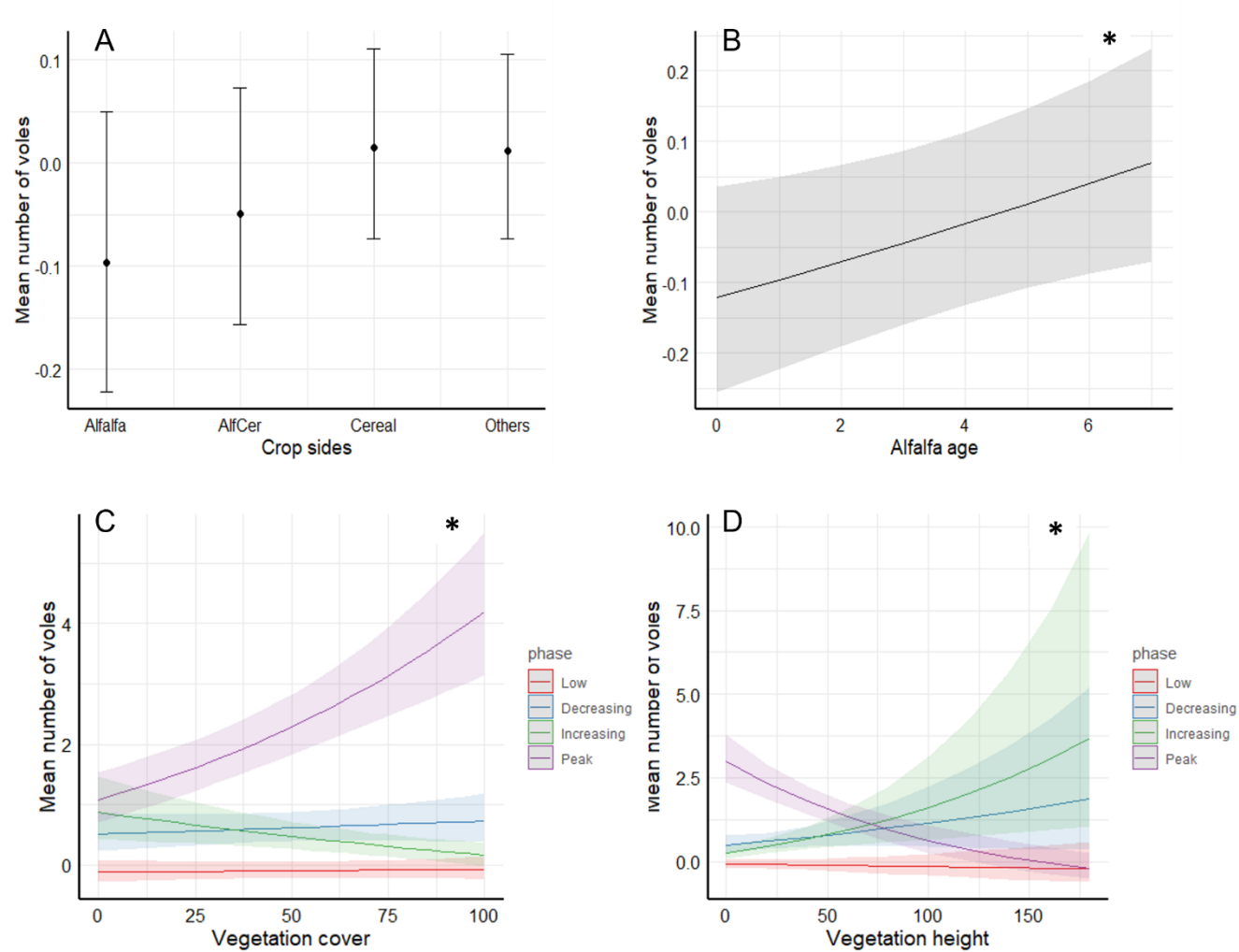


Figure C2. Effects of the models with the lowest AIC value for the trapping point scale. Significant effects are highlighted by an asterisk (* $p < 0.05$).

Appendix D – Trapping point scale model

Table D1. Significance values of the explanatory variables included in the spatially explicit GLMM explaining vole abundance at the trapping point scale.

Variable	Chisq	df	p value
crop.sides	6.14	3	0.105
phase	12.53	3	0.006**
width	1.61	1	0.205
veg.cover	1.93	1	0.165
veg.height	1.22	1	0.270
margin.type	0.70	2	0.704
alfalfa.age	0.58	1	0.447
alfalfa.age ²	0.00	1	0.948
phase:width	1.60	3	0.659
phase:veg.cover	4.00	3	0.262
phase:veg.height	3.60	3	0.308

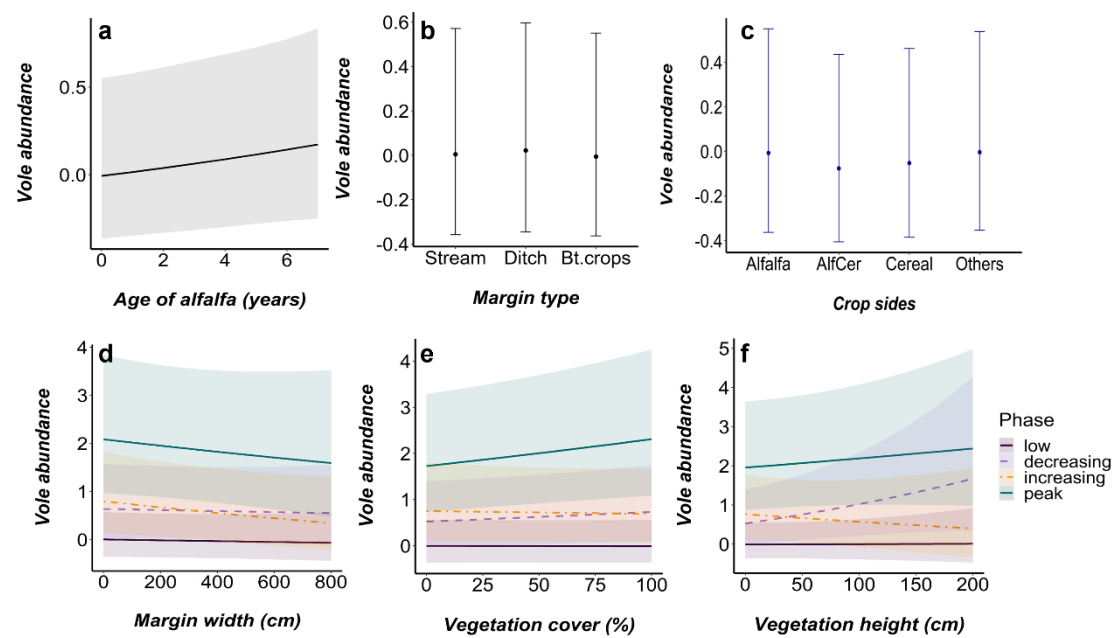


Figure D1. Effects of environmental variables on vole abundance at the trapping point scale. Solid lines (a, d, e, f) and dots (b, c) represent model fit and shaded areas and bars represent the 95% confidence intervals for continuous and categorical variables, respectively.