How to manage habitats of the endangered lycaenid butterfly *Lycaena helle* (Denis & Schiffermüller, 1775) (Insecta, Lepidoptera)

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Abstract. The violet copper *Lycaena helle* (Denis & Schiffermüller, 1775), one of the rarest butterflies in Europe, has several small populations left in the north-western part of Luxembourg. Habitat loss as well as wrong management has led to huge losses resulting in a small number of highly scattered populations in the Oesling region. More than ever, it is crucial that remaining occupied sites as well as potential sites are managed in the appropriate manner. This publication proposes a management plan for different quality of sites (ranging from good quality sites to unsuitable but potential sites) based on studies and suggestions by various authors. The management plan is set up to benefit both *Lycaena helle* and *Proclossiana eunomia,* another glacial relict species on the Red List of butterflies in Luxembourg. Hopefully, this management plan will be used as a guideline during the current LIFE 'Éislek' project (2012- 2017) as well as future projects with *L. helle* as a target species. The experience in the field will then help to adapt the various management options in order to find the best possible way to manage a site for these endangered wetland butterflies.

1. Introduction

1.1. *Lycaena helle* – a glacial relict species

The Violet copper *Lycaena helle* (Denis & Schiffermüller, 1775) (Fig. 1) is a typical glacial relict species with isolated populations ranging from Central Europe to Scandinavia over to Northern Asia (Meyer 1981a,b; Habel et al. 2008; Finger et al. 2009). It is considered as one of the rarest butterfly species in Central Europe showing a continued decline throughout its range (Fisher et al. 1999; Wipking et al. 2007; Finger et al. 2009; van Swaay et al. 2012). Its current distribution in Central Europe is limited to altitudes above 400 m (e.g. Ardennes, Eifel, Westerwald, the Massif Central and Vosges) (Meyer 1981b; Wipking et al. 2007; Habel et al. 2008). The natural habitats of this species have consisted of bogs or moorlands, which have become scarce. Nowadays, most populations can be found on abandoned wet meadows along streams, springs or lakes (Fisher et al. 1999; Wipking et al. 2007; Bauerfeind et al. 2009; Chuluunbaatar et al. 2009; Finger et al. 2009; van Swaay et al. 2012).

Males are highly territorial, with their territories being often in close proximity to



Fig. 1. *Lycaena helle.* Sporbech (Troine), Photo: Marie Kayser.

shrubs or trees, which function as wind protections. Females occupy more sun-exposed areas to deposit their eggs. Both male and female adults roost in tall trees (Goffart et al. 2001, 2010). The population of Central Europe is univoltine and flies from May until June (Meyer 1982; Fisher et al. 1999; Wipking et al. 2007; Finger et al. 2009). Their dispersal ability is very poor (Meyer 1981 b; Fisher et al. 1999; Chuluunbaatar et al. 2009). In Central Europe, the larva is specialised on a single host plant, the Common bistort *Polygonum bistorta* (Wipking et al. 2007; Finger et al. 2009; van Swaay et al. 2012). *L. helle* overwinters as a pupa in the leaf litter (Fisher et al. 1999; Wipking et al. 2007; van Swaay et al. 2012).

The main threats to the survival of this rare butterfly are habitat loss due to various factors like intensification of agricultural practices (land drainage and deterioration of wetlands), wrong management of occupied sites or afforestation (Fisher et al. 1999; Wipking et al. 2007; Bauerfeind et al. 2009; Chuluunbaatar et al. 2009). Furthermore, increased fragmentation as well as ever increasing isolation of the different populations makes for an imminent threat to the long-term survival of this butterfly (van Swaay et al. 2012). Throughout Europe nine different subspecies have been recognised (Meyer 1981 a; Habel et al. 2008; Habel et al. 2010; Habel et al. 2011).

The species is classified as endangered under the IUCN Red List for European Butterflies (van Swaay et al. 2010) and is listed on the Annex II and IV of the Habitat Directive (EEC 92/43/EWG) of the European Union.

1.2. Current situation of *L. helle* in Luxembourg

L. helle is found in the north-western part of the Oesling region (Fig. 2). Monitoring in 2013 found 29 sites occupied by *L. helle* (unpublished data). Fieldwork was carried out as part of a Masters Degree at the University of Leeds in collaboration with the LIFE 'Éislek' project (2012-2017). *L. helle* mainly occupies wet meadows with various densities of its host plant (personal observation). Occupied sites form a relatively well connected cluster in the very northern part of Luxembourg, but become more and more isolated further south near the river Sûre (Fig. 2). Occupied and potential sites are often either surrounded by high intensively used agricultural fields or spruce forest. Run-offs often highly increase the nutrient level on these sites, resulting in the loss of the typical flora of wet meadows due to the dominance of high nutrient indicator plant species, like nettles (*Urtica* spp.). Clear felling of large sectors of spruce forest, imminently surrounding occupied sites can result in total exposure of the sites, leaving no wind protection or roosting places. Therefore, these factors pose an imminent threat to the survival of *L. helle* in Luxembourg.

2. *Lycaena helle* habitat management in Luxembourg

2.1. Current management schemes practiced in Luxembourg

A large number of sites currently occupied by *L. helle* are either owned by the nature conservation foundation 'natur&ëmwelt – Fondation Hëllef fir d'Natur' or managed by them. Until recently, their main management strategies for occupied and potential sites were grazing by a high-density flock of sheep or leaving sites unmanaged (personal observation). Additionally, grazing was often conducted at a too early stage, often starting in early June. As many studies found that sheep have a strong negative effect on the host plant due to trampling of the rhizomes and can cause highly detrimental effects on the population of *L. helle* (Wipking et al. 2007; Turlure et al. 2009; Goffart et al. 2010; van Swaay et al. 2012) this management strategy is currently being revised.

Leaving sites unmanaged will eventually result in recolonisation by shrubs and trees resulting in afforestation. Thus, to prevent further loss of good quality and potentially good habitats, sites should always be under some kind of long-term management.

2.2. Proposed management options

All management options presented here are based on studies and recommendations by Goffart et al. (2010), Turlure et al. (2008), Meyer & Helminger (1994), as well as van Swaay (2012). These options are chosen and described specifically to benefit both *L. helle* and *Proclossiana eunomia*, another glacial relict species on the Red List of butterflies in Luxembourg (Meyer 2000). None of these options should be used in an intensive approach in order to avoid any further unnecessary destruction of the local *L. helle* populations.

2.2.1. Mowing

Mowing at any time of the year will always result in detrimental effects on *P. eunomia, L. helle* being only sensitive to too early mowing. Late mowing (after August) has negative effects on *P. eunomia* as it will remove grass tussocks on which caterpillars are dependent for basking, but showing no negative effects on *L. helle*. Early mowing (between May and July) has detrimental effects on both butterfly species, as caterpillars and pupae will be killed or removed from the site.

Mowing itself can have beneficial effects, as it increases the abundance of flowering plants. As a result, mowed sites increasingly attract adults of *L. helle* both for feeding and egg laying. Adults of *P. eunomia*, however, strongly avoid these patches the following year due to a lack of grass tussocks.

All cut material should be removed from site to prevent increases in soil nutrients.

2.2.2. Grazing

Overall, the negative impact of grazing on butterfly abundance tends to be lower than for mowing. However, inappropriate or intensive grazing regimes that are conducted either too early (before 1st August) or using high stock densities can have strong negative effects on both species. *P. eunomia* seems to benefit more from late grazing and/or alternately grazed plots. Late grazing (from 1st August) prevents trampling of both host plants and early stages of development of both species as well as the removal of nectar sources during flight period of *L. helle*.

Best results for both species were achieved by alternating grazing regimes in late summer (from August onwards). Grazing is preferably conducted by cattle or horses (ideally Fjord Pony). If this is not possible, grazing by sheep is an option. Under no circumstances, however, should this exceed the maximum stocking rate of 0.2 Livestock Unit (LU)/ha/year. Ideally, a shepherd accompanies flocks to guarantee equal grazing of all areas.

Grazing of occupied or potential sites should only be allowed from 1st August to 1st October.

If sites are too small (<1 ha), grazing as a management option should be re-evaluated or only conducted over a short period of time (maximum 1 week) without exceeding the stocking rate of 0.2 LU/ha/year.

Neither management option (grazing or mowing) should be considered the only option on favourable sites. Under no circumstances should early mowing or grazing be applied to the whole site or to the same site for several consecutive years, as it could potentially wipe out the entire population of larvae and/or pupa of both butterfly species.

2.2.3. Areas under no management

On occupied sites it is highly recommended to leave an area, which includes both wind protection and high density of sun-exposed host plants. These areas provide important refuge areas for both butterfly species throughout all life stages.

2.2.4. Planting

If it is necessary to plant trees and/or shrubs, all plants should be protected against grazing for the first few years. Planting of shrubs should occur randomly (e.g. not in line) and should be completely exposed. The species of shrubs and trees to be planted should be selected according to their natural occurrence on wet meadows or in the region (e.g. shrubs: *Salix* sp.; trees: *Betula alba*).

Planting hedges (solitary structures, clusters or lines) should be considered on sites solely

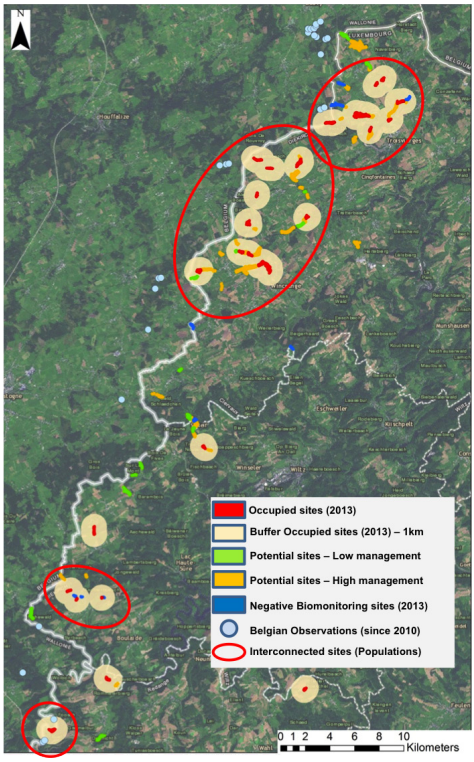


Fig. 2. Occupied sites found in 2013 during a Masters project conducted at the University of Leeds in collaboration with the LIFE 'Éislek' project. Occupied sites (red) show a buffer zone of 1 km to indicate the connectivity between sites (being half the distance between sites favourable for recolonisation). Unoccupied sites were recorded and classified as either 'Low management' (green) – sites could potentially be colonised without major changes – or 'High management' (orange) – sites need to be managed/ restored before the butterfly could colonise it. Negative Biomonitoring sites (blue) show sites, which were occupied between 2010-2012 (Biodiversity Monitoring conducted by MNHN and CRPGL) but not in 2013.

surrounded by spruce forest. Often these forests provide the only wind protection and when clear felled, leave the site completely exposed to strong winds. Planting hedges (and/or trees) along the borders could prevent the degradation or even improve the site quality.

2.3 Proposed management plan

The different management options described above can be used in various intensities over several years, but should always be adapted according to the condition of the site in question. An occupied site in a bad quality (e.g. low host plant density, no wind protection; Fig. 5) needs a more intense management plan than a good quality site (e.g. high host plant density, good wind protection; Fig. 3), which may be unoccupied. Furthermore, neither grazing nor mowing should be used as the only option on occupied sites as both have direct (mowing – decreasing the population) or indirect (grazing – dominating plants like meadsweet are avoided) negative effects on the *L. helle* population.

The management plan is therefore divided into the different categories of site quality (Table 1 for the different criteria) set up in a



Fig. 3. Good quality site – high density of host plant, good wind protection, enough roosting possibilities and high density of nectar sources.



Fig. 4. Satisfactory quality site – high host plant density only found in patches, high density of dominating plant species (here meadsweet), low nectar sources densities, good wind protection and enough roosting possibilities.



Fig. 5. Unfavourable quality site – host plant scattered between dominating plants (here meadsweet), site exposed to wind, no good roosting possibilities, very low density of nectar sources.



Fig. 6. Site unsuitable at the moment – no host plants present, too high density of dominating plants (here meadsweet), site exposed to wind, good roosting possibilities, no or low densities of nectar sources

Table 1. Criteria by which the different states can be assigned to individual sites, depending on the overall habitat quality, as suggested by CRNFB (2006). State 'unsuitable' was added as an additional state for habitats where no host plants were present but could become a potentially sites for *L. helle* as a result of ongoing (current) restoration efforts. The indicator 'Density of dominating plants' was added as an additional indicator as it is highly important for the intensity of certain management options. All Indicators must fit in the same 'State' category otherwise the site will be degraded to the next lower 'State'.

Indicator	State 'good'	State 'satisfactory'	State 'unfavourable'	State 'unsuitable'
Minimal surface	> 0.75 acre	0.50 – 0.75 acre	< 0.50 acre	N/A
Density of host-plant	> 50 %	25 – 50 %	< 25 %	0 %
Density of flowering plants	> 5 %	1 - 5 %	< 1 %	N/A
Density of dominating plants (e.g. nettles or/and meadsweet)	> 10 %	10 – 50 %	50 – 75 %	> 75 %

Table 2. Management plan for the different habitat quality states.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
State 'good'	Mowing (1/3)		Grazing (2/3)	Mowing (1/3)		Grazing (2/3)
State 'satisfactory'	Mowing (1/3)	Early restorative mowing (1/3)	Mowing (1/3) Grazing (2/3)	Early restorative mowing (1/3)	Mowing (1/3)	Early restorative mowing (1/3) Grazing (2/3)
State 'unfavourable'	Restorative mowing (2/3)	Restorative mowing (2/3) Reassessment of site	State improved – start management plan for State 'satisfactory'			
			State unimproved - Restorative mowing (2/3) with reassessment of site every year			
State 'unsuitable'	Restorative mowing	Restorative mowing	Restorative mowing Reassessment of site	State improved – start management plan for State 'unfavourable'		
				State unimproved - Restorative mowing with reassessment of site every year		

6-year rotation plan (Table 2). No matter the site quality, one third of the site should always be left without management each year.

2.3.1. Good quality site – State 'good' (Fig. 3)

Sites should be divided into thirds (every third should include: high density of food plants, shrubs and be of approximately equal size. None of the thirds should be more than 500 m from the closest tree line or group away to maintain roosting opportunities.)

Rotational mowing of 1/3 every three year after 1st September (starting in year 1).

Extensive grazing on 2/3 with <0.2 LU/ha/year every three years after 1st August (starting in year 3).

At least 1/3 should be left whenever site is managed.

2.3.2. Satisfactory quality site – State 'satisfactory' (Fig. 4)

Sites should be divided into thirds (every third should include: a good density of food plants, shrubs and be of approximately equal size. None of the thirds should be more than 500 m from the closest tree line or group away to maintain roosting opportunities).

Rotational mowing of 1/3 every other year after 1st September (starting year 1).

Early restorative mowing of 1/3 every other year beginning 1st July (starting year 2) – only necessary in thirds where dominating plants have a too high density.

Extensive grazing on 2/3 with <0.2 LU/ha/ year every three years after 1st August (starting in year 3)

At least 1/3 should be left whenever site is managed.

2.3.3. Unfavourable quality site – State 'unfavourable' (Fig. 5)

Sites should be divided into thirds (every third should include, if possible: some food plants, shrubs and be of approximately equal size).

Restorative mowing on 2/3 of the site for first two years, at least twice during the season beginning 15th June. Grazing can be used instead of second mowing date, but never as sole option for restoration purposes (starting year 1).

At least 1/3 should be left whenever site is managed

For very large areas (> 2 ha): divide site into two – each 1/2 is alternatively mowed or grazed every year, leaving the other 1/2 without management.

After two years reassessment of site:

(a) Still unfavourable condition: continue restorative mowing;

(b) Condition favourable: adapt management option for favourable conditions (restart from year 1);

(c) Planting of shrubs and/or trees should be conducted at this stage if necessary.

2.3.4. Potential but unsuitable sites – State 'Unsuitable' (Fig. 6)

Restorative mowing for the first three years, at least twice during the season – starting 15th June. Grazing can be used instead of second mowing date, but never as sole option for restoration purposes.

After three years reassessment of site:

(a) Still unsuitable condition: continue restorative mowing (reassess site every year)

(b) Condition improved: adapt management option for unfavourable conditions (restart from year 1). Planting of shrubs and/or trees should be conducted at this stage if necessary.

If lack of nearby site with host plant, which would enable natural recolonisation, seeding or transplanting host plant should be considered at this stage.

Management should never be too intensive. If sites are in unfavourable condition, stronger management options can be considered for a period of time in order to restore the site into a higher quality habitat. Once this status has been reached, management options need to be adapted so butterflies can (re-) colonise. It is therefore crucial to regularly assess the state of the sites and adapt management options accordingly.

Regular monitoring of occupied and potential sites is highly advised. The changes in densities in both *L. helle* and *P. eunomia* populations can indicate which methods are the best to secure a good healthy population of both butterfly species in Luxembourg.

3. Discussion

3.1. Theory vs Practical Conservation

While all of the above-mentioned management suggestions may represent an ideal case scenario, their practical application may not always be possible. Environmental conditions like excessive water may prevent work at certain times of the year. Some sites are inaccessible for heavy machinery altogether. Given that the overall aim of all here proposed management options is to prevent sites from being dominated by some (unwanted) plant species in the short term or from afforestation in the long term, the frequency of management could be reduced to a bare minimum. This may well be far less than the proposed measures. For these sites the sole management option may consist of a restorative mowing every 3-4 years, rather than persistent grazing by sheep (which are often left in too high densities over a long period of time). When it comes to managing habitat for *L. helle*, by far the most imminent threat probably lies in over- rather than under-managing sites.

3.2. The future of *L. helle* in Luxembourg

Current changes in climate and continuing intensification of agricultural practices are both high imminent threat for the flora and fauna of wet meadows in the Oesling region. Additionally, the population of *L. helle* is highly isolated and scattered over a great area. Connections to the Belgian population have often been disrupted due to habitat deterioration or loss. Therefore, the collaboration of different organisations (national and international) and the exchange of ideas and experience should continue to play an important role in the conservation strategies for our interregional population.

To prevent further decline of the Ardennes populations in Luxembourg, as many sites as possible should be managed to benefit not just the flora, but also the threatened fauna, like *L. helle* and *P. eunomia*. Continuing the current management strategy for wet meadows practiced in Luxembourg will, however, result in further decline and eventually the regional extinction of this beautiful little survivor.

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