A Twig Lichen transect at Brynna a Wern Tarw SSSI

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Background

Brynna a Wern Tarw SSSI is an important site for marshy grassland, neutral grassland and wet heath north of Bridgend. It formerly supported a population of Marsh Fritillary butterfly, but this species has been lost since the site was notified as SSSI in 2003. Modelling by UKCEH using the EMEP model suggests that the SSSI receives 1.3µg/m^3 of ammonia pollution per year, which is above the Critical Level (CLe) for bryophyte- and lichen-rich ecosystems (1 µg/m^3) but below the CLe for vascular plant-dominated ecosystems (3 µg/m^3). Nevertheless, changes in the vascular plant flora have been noted since the 1990s (Gill Barter, NRW pers. comm.) and possible links between these changes and air pollution are being considered by NRW staff.

Measuring N-deposition on a site requires specialist equipment, such as Alpha-sampler diffusion tubes or active Delta-samplers. There is, however, a method for determining whether an area is N-polluted without such equipment. The Twig Lichen Survey approach (Hope, 2018), modified from that developed by Wolseley et al., (2017) to include recording of all N-sensitive and N-tolerant species, gives a Lichen Index Score that shows whether an area is Very N-polluted, N-polluted, At Risk or Clean. Although the results are not as quantitative as direct N sampling, they do show general trends and are derived from a peer-reviewed, UK-wide methodology.

The current survey used the Twig Lichen Survey approach to investigate N pollution on one part of Brynna a Wern Tarw SSSI.

Methods

The Twig Lichen Survey approach involves recording the presence of N-tolerant and N-sensitive lichens on three zones of five twigs on each surveyed Oak tree. There was insufficient time during the visit on 16th May 2023 to carry out the protocol in full, but qualitative observations of five trees were made. N-sensitive species and N-tolerant species were examined on each tree, but not in detail zone by zone. Oak trees were selected from a distance as being sufficiently well-lit to support lichens, and all had branches which were low enough to allow examination. The route taken formed a rough transect 500m long from the middle of the SSSI to its western edge, approaching the Rockwool factory which lies just to the west of the SSSI (Fig. 1).

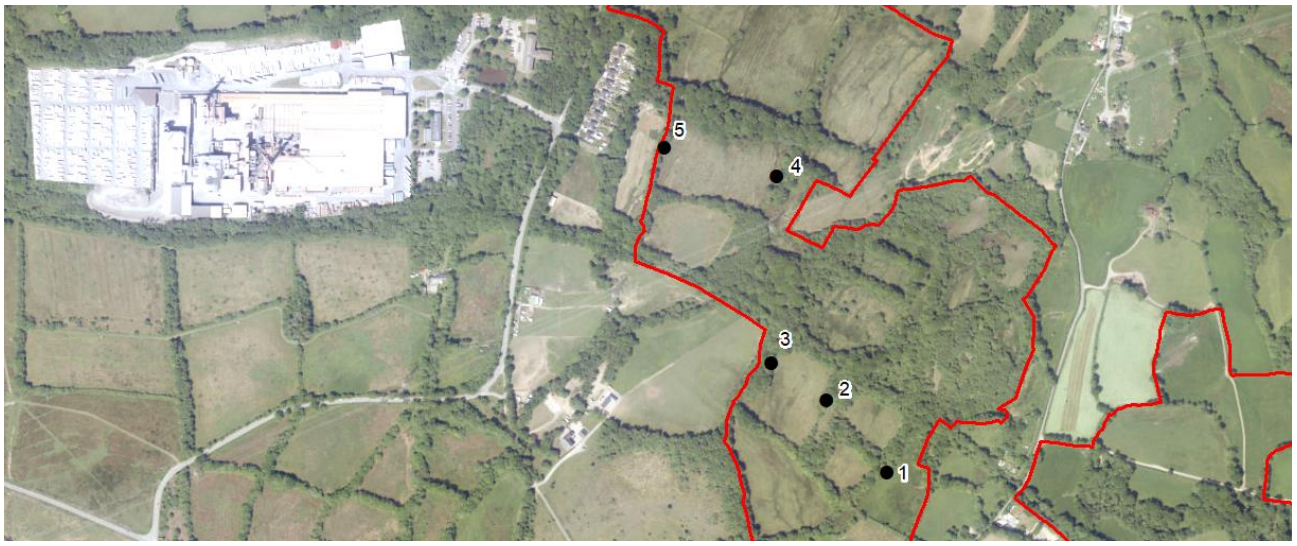

Figure 1: five Oak trees (black dots) on which Twig Lichens were examined in part of Brynna a Wern Tarw SSSI (red outline).

Subsequent visits on 5th July and 12th October 2023 allowed more detailed recording to be carried out on eleven trees with a wider distribution on the SSSI (Fig. 2). This recording followed the Twig Lichen Survey approach precisely, allowing the derivation of exact Nitrogen Air Quality Index (NAQI) results. Five branches were selected on well-lit, accessible sections of each oak tree (in a few cases two adjacent trees were recorded because individual trees had insufficient accessible branches), and each divided into three zones 50cm long. N-sensitive and N-tolerant lichens as listed in Hope (2018) were recorded in each zone and their presence was used to calculate a Lichen Indicator Score (LIS) and then an NAQI for each tree.

Figure 2: 11 Oak trees (blue dots) on which full Twig Lichen Surveys were carried out in part of Brynna a Wern Tarw SSSI (red outline).

Results

During the first visit, notes were taken on five Oak trees (Table 1), four of which were photographed (Figs 4-7).

Table 1: notes on N-sensitive, mesotrophic and N-tolerant lichens on five Oak trees at Brynna a Wern Tarw SSSI.

Tree	Grid Reference	N-sensitive Lichens	Mesotrophic Lichens	N-tolerant Lichens	Likely N Level
1	SS968835	Occasional *Evernia*, Occasional *Hypogymnia*, Rare *Usnea*, Rare *Graphis*	Abundant Parmelioid lichens	Occasional *Physcia*, Rare *Candelaria concolor*	At Risk
2	SS967836	Rare *Graphis*	Frequent Parmelioid lichens	Frequent *Candelaria concolor*, Frequent free algae	N-polluted
3	SS966837	Absent	Occasional Parmelioid lichens	Frequent *Candelaria concolor* Frequent free algae, outer 1m of twigs bare	N-polluted
4	SS967840	Absent	Occasional Parmelioid lichens	Frequent *Candelaria concolor* Abundant free algae	N-polluted
5	SS965840	Absent	Frequent Parmelioid lichens	Frequent *Candelaria concolor*, Occasional *Xanthoria*, Frequent free algae	N-polluted

During the second visit, NAQI scores were calculated for 11 oak trees. Four of these (trees 1 to 4) were the same as those for which notes and photographs were taken on the initial visit; tree 5 did not have suitable branches for sampling so the nearby tree 6 was sampled. Three additional trees in the western fields (trees 7 to 9) and three additional trees in the eastern fields (trees 10 to 12) were examined.

Table 2: Lichen Indicator Scores and Nitrogen Air Quality Indicators for 11 Oak trees at Brynna a Wern Tarw SSSI (tree 5 was not sampled during this survey but tree 6 is nearby).

Tree	Grid Reference	Lichen Indicator Score	Nitrogen Air Quality Index	N pollution level
1	SS96848352	0	0.8	At risk
2	SS96788363	-1.6	1.2	N polluted
3	SS96678362	-0.2	0.9	N polluted
4	SS96718394	-2.4	1.4	Very N polluted
6	SS96558420	-1.6	1.2	N polluted
7	SS96748426	-2.4	1.4	Very N polluted
8	SS96708408	-0.8	1	N polluted
9	SS96628403	-2.4	1.4	Very N polluted
10	SS96908381	-0.6	1	N polluted
11	SS96908389	-0.4	0.9	N polluted
12	SS96968353	-0.4	0.9	N polluted

The eastern fields held a higher cover and diversity of wetland plants than the western ones, but species such as *Cirsium dissectum*, *Dactylorhiza maculata* and *Pedicularis sylvatica* remain locally abundant in the closest fields to the Rockwool factory, along with locally frequent *Sphagnum inundatum* and *S. subnitens*. There appears to be a lower frequency and cover of *Succisa pratensis* in the western fields compared with its high cover in the eastern fields (Fig. 8).

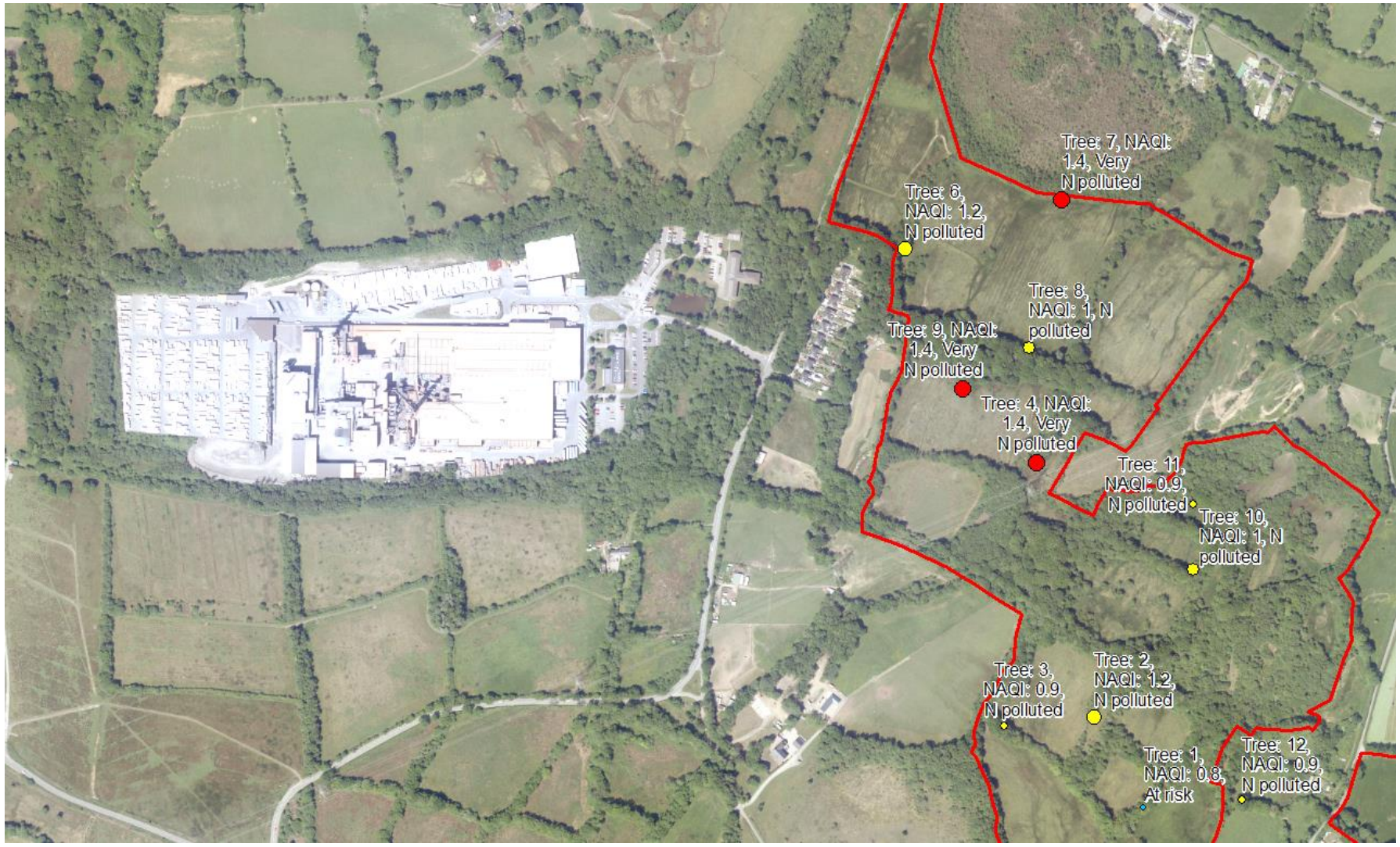

Figure 3: Twig Lichen Survey NAQI (Nitrogen Air Quality Index) scores for 11 oak trees in part of Brynna a Wern Tarw SSSI (red outline), with symbols scaled by NAQI score (largest being most polluted) and coloured according to N pollution level: blue=At risk; yellow=N polluted; red=Very N polluted.

Figure 4: outer branches of tree 1, supporting abundant Parmelioid lichens and the N-sensitive species *Hypogymnia physodes* (arrowed).

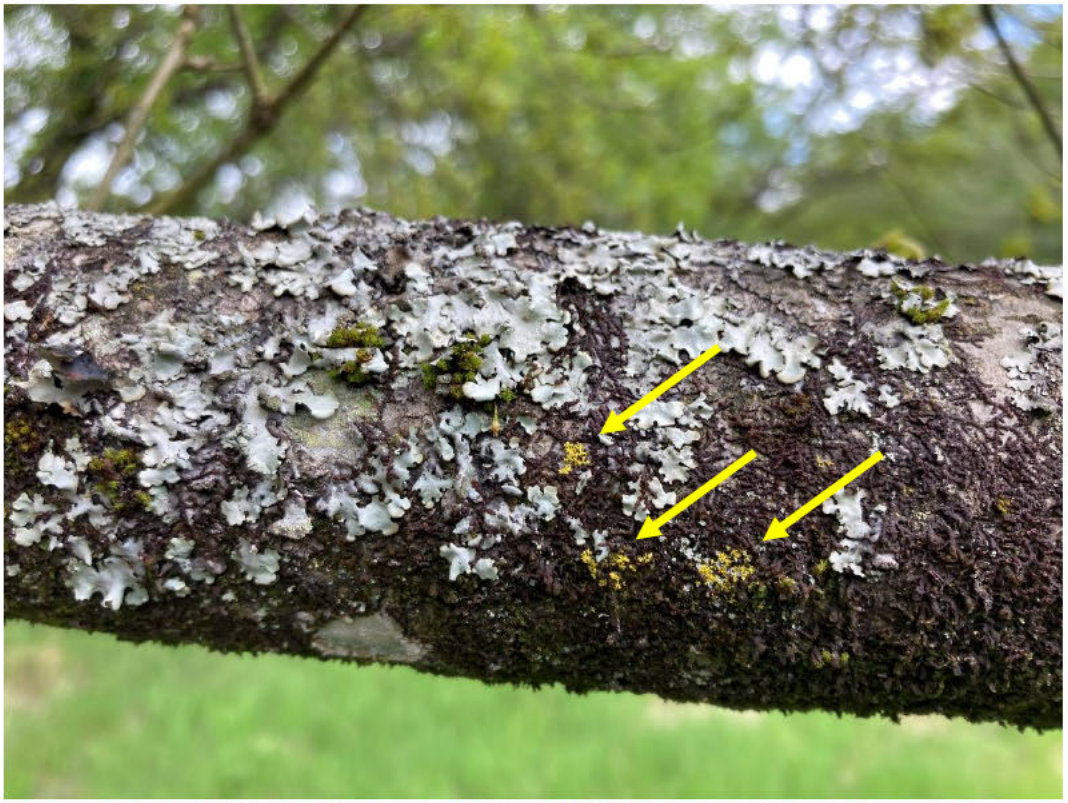

Figure 5: part of the outer branch of tree 2, with frequent orange *Candelaria concolor* (arrowed).

Figure 6: outer branches of tree 4, with very little lichen cover.

Figure 7: outer branches of tree 5, with a large thallus of the N-tolerant *Xanthoria parietina* (arrowed) as well as frequent spots of orange-yellow *Candelaria concolor*.

Figure 8: a high cover of *Cirsium dissectum* and *Succisa pratensis* in the eastern fields.

Discussion

The twig lichens at Brynna a Wern Tarw show a clear deterioration in abundance along a 500m transect from south-east to north-west. The south-easternmost tree (tree 1) holds four species of N-sensitive lichen and only two N-tolerant species, and was subsequently shown through Twig Lichen Survey to fall into the 'At Risk' category, albeit marginally. Tree 2 was found to support a single patch of an N-sensitive species, *Graphis scripta*, and that was discoloured by 'free' algae (generally the result of increased N): Twig Lichen Survey revealed this to be in the 'N polluted' category. The twig lichens in the western fields, closest to the Rockwool factory, entirely lack N-sensitive species and even the mesotrophic Parmelioid lichens are of limited extent. Frequent to abundant *Candelariella reflexa* and the appearance of the nitrophilous *Xanthoria parietina* suggest that these trees are at the more polluted end of 'N-polluted', and several were actually shown by Twig Lichen Survey to be 'Very N polluted'. The transect, backed up by survey of additional trees, strongly suggests that N levels are much higher on the western edge of the SSSI than in the centre, and given the lack of ammonia and NOx sources within the SSSI this will certainly be the result of activities outside the site. It is notable that within the western fields, the 'Very N polluted' trees are facing westwards, whereas those facing north or east are mostly 'N polluted', potentially because the narrow blocks of woodland between the fields are providing some shelter from N pollution that is entering the site from the west.

The reduced abundance of twig lichens correlates well with the observed low frequency and cover of *Succisa pratensis* in the western fields compared with those further east on the SSSI. However, this correlation cannot be seen as causation because the western fields have been subject to different historic and current management and *Succisa* is absent from the areas of rush-pasture now found along defunct former drainage lines across large parts of these fields. Nevertheless, the stands of M24 marshy grassland between the areas of rush-pasture appear ideal for *Succisa*, and indeed some do hold it at low cover. Annual monitoring of the frequency and cover of *Succisa* and selected other grassland forbs might be a way of detecting whether N pollution is causing damage to the SSSI grassland feature, because studies in Somerset have shown N causing sharp declines in some wetland plant species: "The forbs, which are characteristic of these old meadows, declined sharply in number and some, for example *Cirsium dissectum*, *Lychnis flos-cuculi* and *Lotus pedunculatus*, disappeared from nitrogen-treated plots" (Bobbink *et al.*, 2003 p. 724).

The twig lichen records and subsequent Twig Lichen Survey also correlate well with ammonia monitoring carried out by CEH on behalf of Rockwool in the western fields between 2009 and 2011. This shows annual mean ammonia concentrations between 1.4 and 2.2 $\mu g/m^3$, levels that are well above the Critical Level for lichen-rich ecosystems, but also shows a decreasing trend in ammonia concentrations as distance from the Rockwool factory increases. The possibility that the N enrichment has an agricultural source rather than originating from Rockwool must not be discounted, but UKCEH modelling shows there are relatively low levels of agricultural N emissions to the west and south-west of the SSSI (Fig. 4).

The extent to which emissions from Rockwool are actually damaging the epiphytic lichens (which are not a feature of the SSSI, merely a component of the wider vegetation) or the marshy grassland might be determined by further monitoring of both aspects of the site's

vegetation. Repeating the Twig Lichen surveys would document deterioration/recovery, and ideally this would be combined with reinstatement of ammonia monitoring using Alpha Samplers. A protocol for monitoring the abundance of wetland forbs, including the N-sensitive *Cirsium dissectum* and *Succisa pratensis*, is needed, but needs careful design to account for the hydrological and management variation across the site. Again, combining monitoring of the marshy grassland with ammonia monitoring would help to determine potential causes of any changes in species abundance.

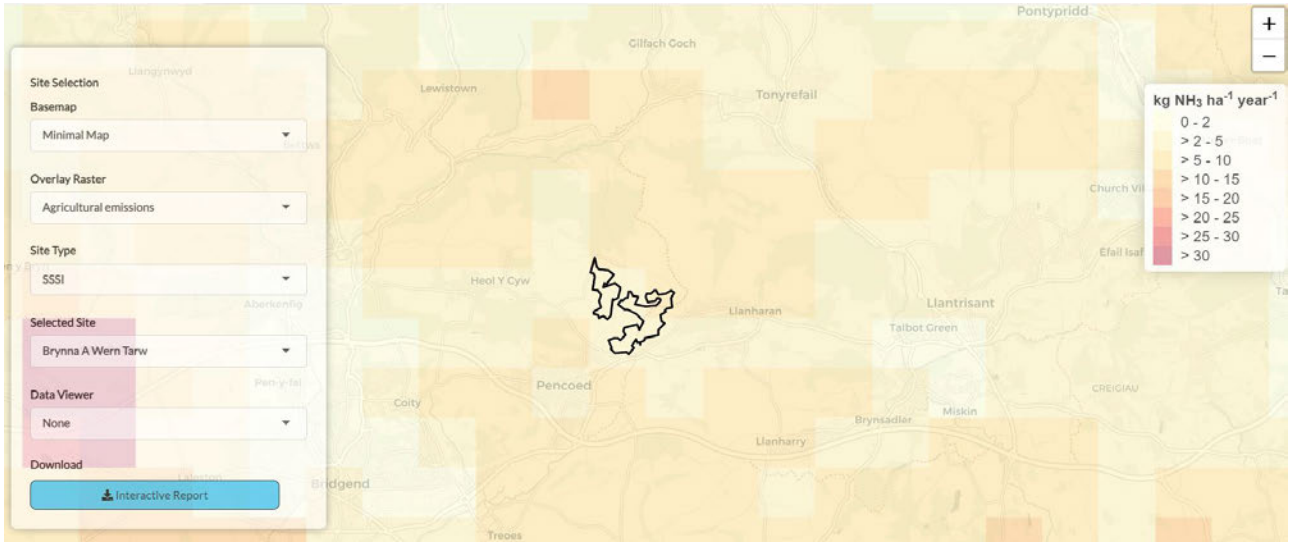

Figure 4: agricultural ammonia emissions in the area around Brynna a Wern Tarw SSSI, modelled by UKCEH using agricultural census data.

The current survey demonstrates that a full Twig Lichen Survey is better able to discriminate between different N pollution levels than is simple noting of the presence of N-sensitive and N-tolerant lichens. This is partly because it is quantitative rather than qualitative, but is also because it largely excludes bias where an observer places more weight on a prominent 'positive' species that is present in small quantity than on a less obvious 'negative' species which is scattered across all the twigs on a tree. Having said that, there is potential for bias through twig selection, and to counter this twigs/branches were selected for closer examination when the tree was first approached rather than after an initial examination. The results might also have been slightly different (with worse NAQI scores) if *Candelaria concolor* had been included as an N-tolerant species because it is frequent on many trees that otherwise held only occasional *Candelariella reflexa* and *Physcia* spp. *Candelaria concolor* certainly thrives in areas with high N levels, but it is generally thought to be an indicator of warmer temperatures than of N pollution.

References

[redacted] 2003. The effects of air-borne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. *Journal of Ecology* **86**: 717-738.

[redacted] 2018. *Lichen surveys to investigate ammonia impacts*. NRW Evidence Report No: 298, 126 pp, Natural Resources Wales, Bangor.

[redacted] 2018. *Gathering twig lichen data for Powys SSSIs to investigate ammonia levels*. In Bosanquet (2018).

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Table 3: full Twig Lichen Survey data for 11 Oak trees at Brynna a Wern Tarw SSSI, with 5 twigs (T1 to T5) on each tree and 3 zones (Z1 to Z3) on each twig. N-sensitive (Sens) and N-tolerant (Tol) species are listed separately. The Lichen Indicator Score (LIS) and Nitrogen Air Quality Index (NAQI) are given for each tree.

		T1Z1		T1Z2		T1Z3		T2Z1		T2Z2		T2Z3		T3Z1		T3Z2		T3Z3		T4Z1		T4Z2		T4Z3		T5Z1		T5Z2		T5Z3				
Tree	GridRef	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	Sens	Tol	LIS	NAQI	Pollution level
1	SS96848352	Gs	Ph		Cr			EpGs	Ph	Ep	Ph			Hp		Ep			CrPh		Cr	Ep	CrPh	Ep	Ph	Psu		CrEp			Psr	0	0.8	At risk
2	SS96788363		CrLe	Gs	ArCr		CrPh				Cr		Ph				Cr		Ph		Ph	Gs			Ar						Ph	-1.6	1.2	N polluted
3	SS96678362	EpU		Ep	Cr	EpGs	Pt							Gs		Gs	Cr		Ar	Gs	Cr		Cr		Ar	Gs	Ar					-0.2	0.9	N polluted
4	SS96718394				PhXp		CrLe Ph		Ph		PhXp		LePh				Ph		CrLe Ph		Le		CrLe		CrLe				PhPs rXp		Ph	-2.4	1.4	Very N polluted
6	SS96558420				Ar		Ph								Psr		CrPsr		Cr				Ph		Cr						ArPh	-1.6	1.2	N polluted
7	SS96748426		Ph		ArCr		PhXp	Gs	Ar		Ar				Ar		Ar				Ph		Ar		Xp		ArLe		Ar		ArCr	-2.4	1.4	Very N polluted
8	SS96708408						Ph						PhPs r						Cr				PhXp			Gs					Ar	-0.8	1	N polluted
9	SS96628403		Ph		Ar				PhXp		PhXp		LePh Xp				Ar		ArPh				Ar		Ar		Ph		LePh Xp		LePh	-2.4	1.4	Very N polluted
10	SS96908381				Cr						Cr						CrPh															-0.6	1	N polluted
11	SS96908389		Ar		CrPh			Gs	Ph		Ph				Cr					GsPs u		EpGs		Gs	Le	Gs	Cr	EpGs	Le			-0.4	0.9	N polluted
12	SS96968353	EpPs u	Psr			EpPs u	Ph	Psu	Ph		Ph		PhXp				CrPh		Ph	Gs	Cr	Gs	Ar					GrU		CrPh		-0.4	0.9	N polluted

Sensitive species: Ep=Evernia prunastri, Gs=Graphis scripta, Hp=Hypogymnia physodes, Psu=Parmelia sulcata, U=Usnea sp

Tolerant species: Ar=Arthonia radiata, Cr=Candelariella reflexa, Le=Lecidella elaeochroma, Ph=Physcia adscendens/tenella, Psr=Punctelia subrudecta, Xp=Xanthoria parietina