UK Centre for Ecology & Hydrology

# Ballynahone Bog SAC Wind Data Analysis January 2019 to June 2020

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# 1 Introduction / background

Local prevailing wind patterns play a key role in atmospheric nitrogen (N) input to designated sites, in terms of local ammonia ($NH_3$) concentrations and N deposition originating from local, regional and transboundary sources. The aim of this study is to investigate local wind patterns and their temporal variability using locally measured weather data. These data were analysed in conjunction with $NH_3$ measurements within and surrounding Ballynahone Bog SAC.

This report aims to:

- Assess the availability of wind data from met stations surrounding Ballynahone Bog SAC
- Assess local wind patterns
- Establish how local wind patterns influence $NH_3$ concentrations

# 2 Wind data analysis

## 2.1 Availability of wind data from met stations surrounding Ballynahone Bog SAC

In 2016, a met station was installed by Ulster Wildlife at Ballynahone Bog SAC, to record, among other parameters, wind speed and wind direction. At the start of the ammonia measurement campaign for the landscape surrounding the bog (February 2019), the met station was unfortunately not operational and no data were recorded until repairs were carried out in July 2019. The station has been semi-operational since July 2019 and intermittently recorded data throughout July to December 2019. At the beginning of 2020, it was noted that wind speed and direction were no longer being recorded on a 24-hourly basis. It is thought that this may be due to the aging power supply system (solar panel and battery) or insufficient power output from the small solar panel to maintain sufficient charge for the battery. Low data capture in late December 2019 may support this theory as this is when power generation from the solar panel would have been at its lowest.

Wind data corresponding to the landscape ammonia measurement campaign (Feb 2019 – present) is therefore incomplete, with no wind information for large periods of time (Feb 2019 – June 2020). To address this issue, NIEA has recently purchased a new weather station with remote download capabilities which was installed in September 2020. In this study we report only the information collected from the original met station installed in 2016, until its final day of recording, on 17th June 2020.

Figure 1 shows data recorded at the Ballynahone met station. Data were captured at 30 minute intervals with wind direction recorded as a percentage of potential data capture at full functionality (one entry every half hour).

This study also assessed the potential of using information collected at nearby met stations as an alternative source of wind data to the measurements recorded from the met station located on Ballynahone bog. Two nearby met-stations were identified from the Met Office MIDAS dataset[1] (Figure 2):

- Lough Fea (~10km to the SW of the site); and
- Portglenone (~15km to the NW of the site).

Data recorded at Lough Fea and Portglenone were more complete than those from the met station located at Ballynahone Bog SAC. For the same months as shown in Figure 3, Portglenone had only three days with < 100% data coverage, and Lough Fea only had 8 days < 100% data coverage.

[1] Met Office (2006): MIDAS: UK Hourly Weather Observation Data. NCAS British Atmospheric Data Centre, *accessed 02/2020*. https://catalogue.ceda.ac.uk/uuid/916ac4bbc46f7685ae9a5e10451bae7c

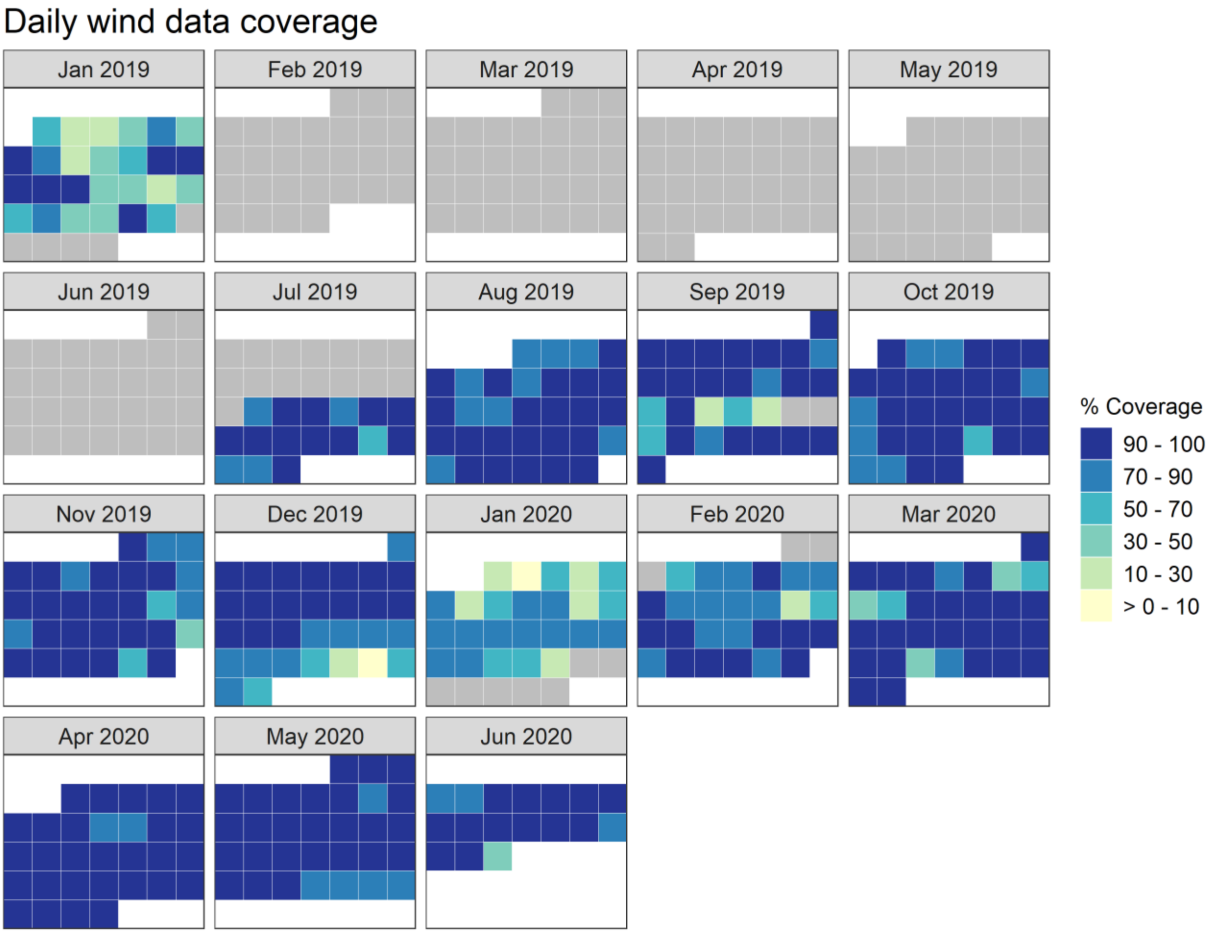


*Figure 1: Daily % of data coverage from Ballynahone met station in 2019-2020, calculated as the percentage of available 30 minute data of the total 24 hour period in each day.*

The land surrounding Lough Fea and Portglenone is higher in elevation and more complex and undulating than the relatively flat terrain surrounding Ballynahone Bog (Figure 2). This makes the two MIDAS Met Office stations potentially less suitable as a proxy for wind patterns at Ballynahone Bog. However, in terms of data capture, the two MIDAS stations are more reliable than the Ballynahone met station. The Portglenone MIDAS station is situated in an area of relatively flat land NE of the bog, and may be sheltered from easterly winds recorded at the Ballynahone met station (due to its location at the foot of a low slope to the east).

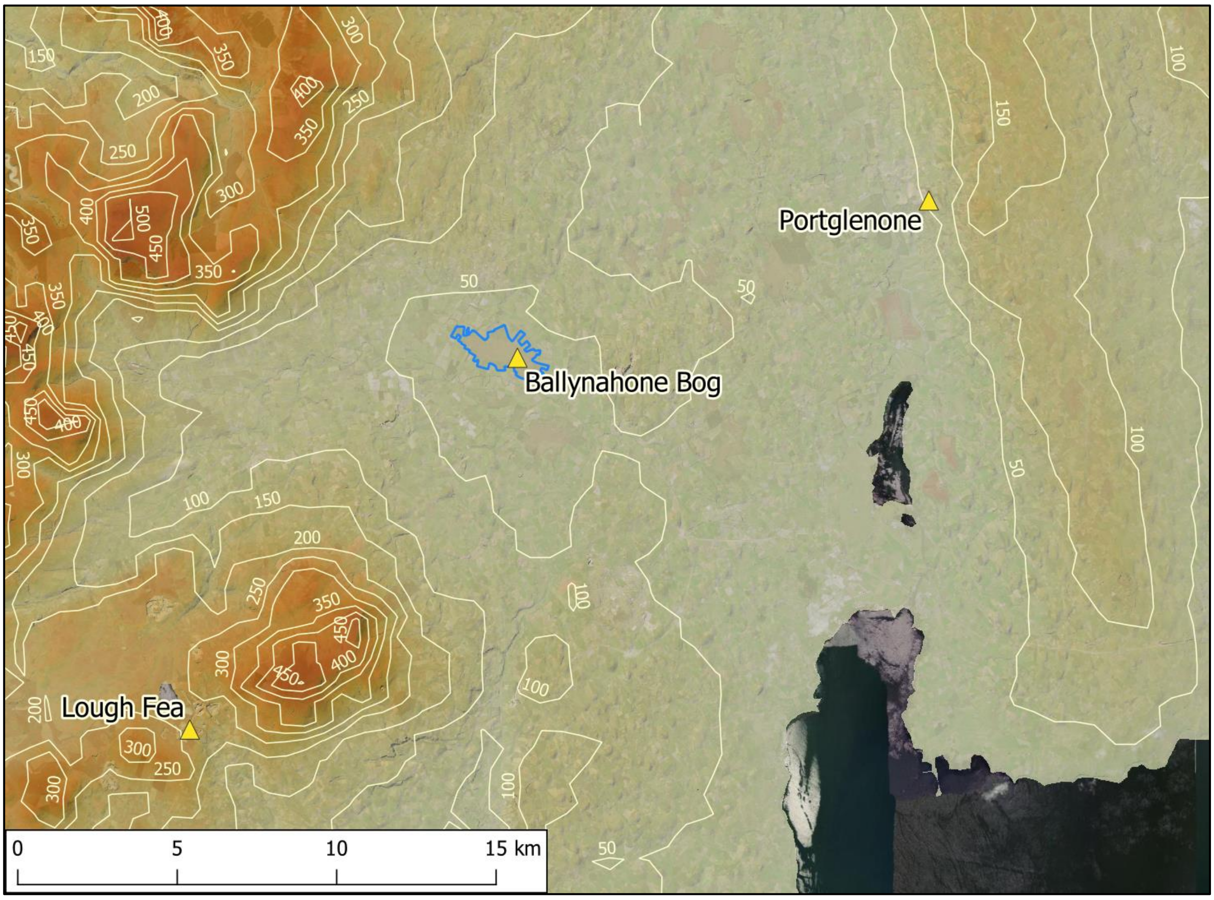


*Figure 2: Map showing location of the Met Office MIDAS Portglenone and Lough Fea met stations in relation to Ballynahone Bog and terrain of the area. Uses OSNI Open Data 10M DTM as elevation data (Land and Property Services 2015). Contains public sector information licensed under the Open Government Licence v3.0.*

## 2.2 Assessment of local wind patterns

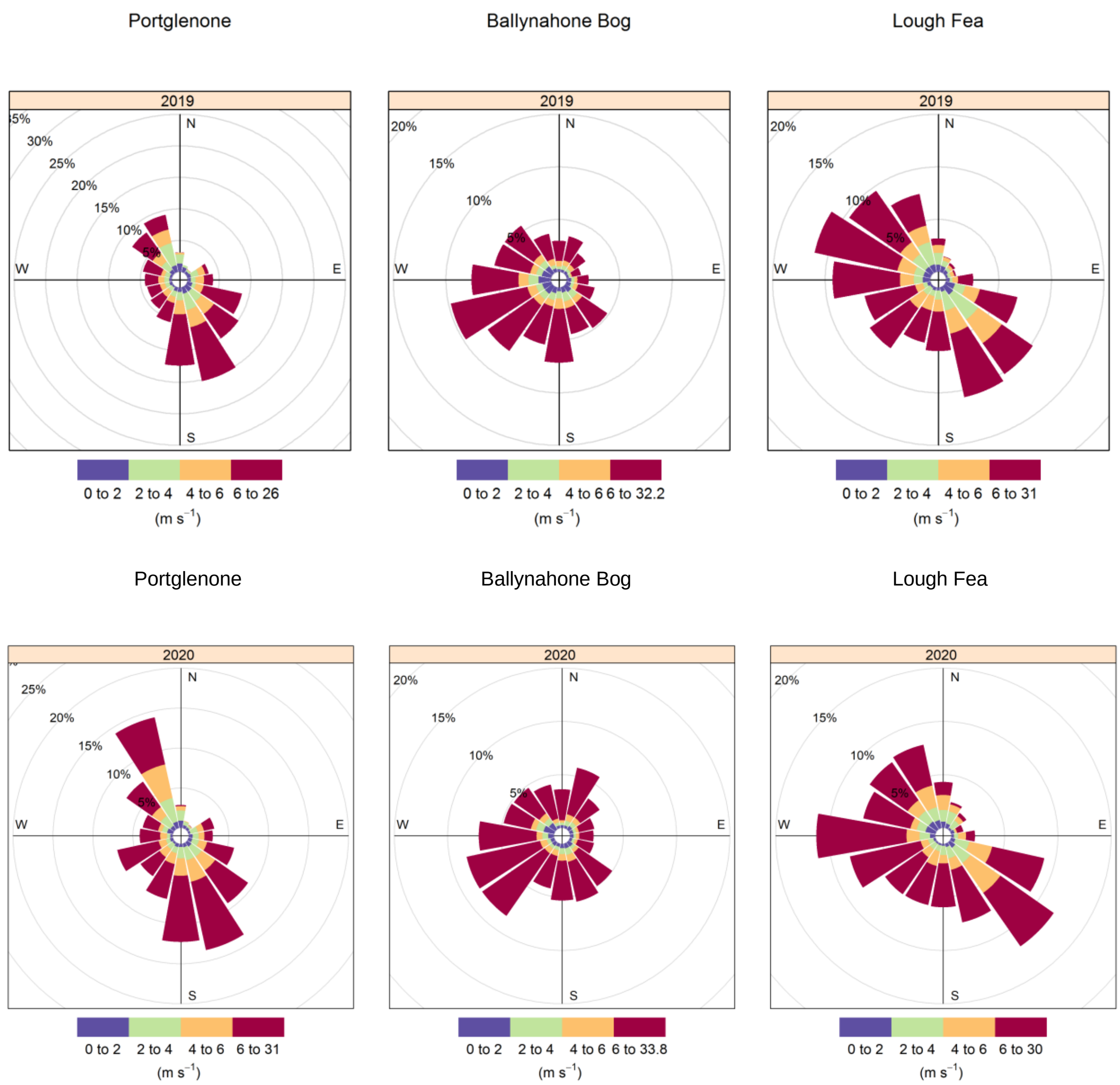


Figure 3: Wind roses for the Met Office MIDAS met stations at Portglenone, Ballynahone Bog and Lough Fea in 2019 and 2020, showing wind speed and direction. Data have been subset to compare only the matching period(s) where data are available.

For the periods in 2019 and 2020 where data are available from all three met stations, Ballynahone Bog shows a prevalence of SW winds (Figure 3). Both Lough Fea and Portglenone show a prevalence of NW/SE winds (Figure 3), which is a consistent pattern across 2014 – 2019 data (data not shown).

When monthly profiles of wind direction are compared between the 3 met stations, Lough Fea shows better agreement in wind direction with the station installed on Ballynahone Bog (Figure 4) than Portglenone. This suggests that Lough Fea could provide useful information to estimate the wind patterns surrounding Ballynahone Bog for the periods where the station was unable to collect data, and for the longer period back to 2014, when $NH_3$ concentrations measurements started on the bog itself.

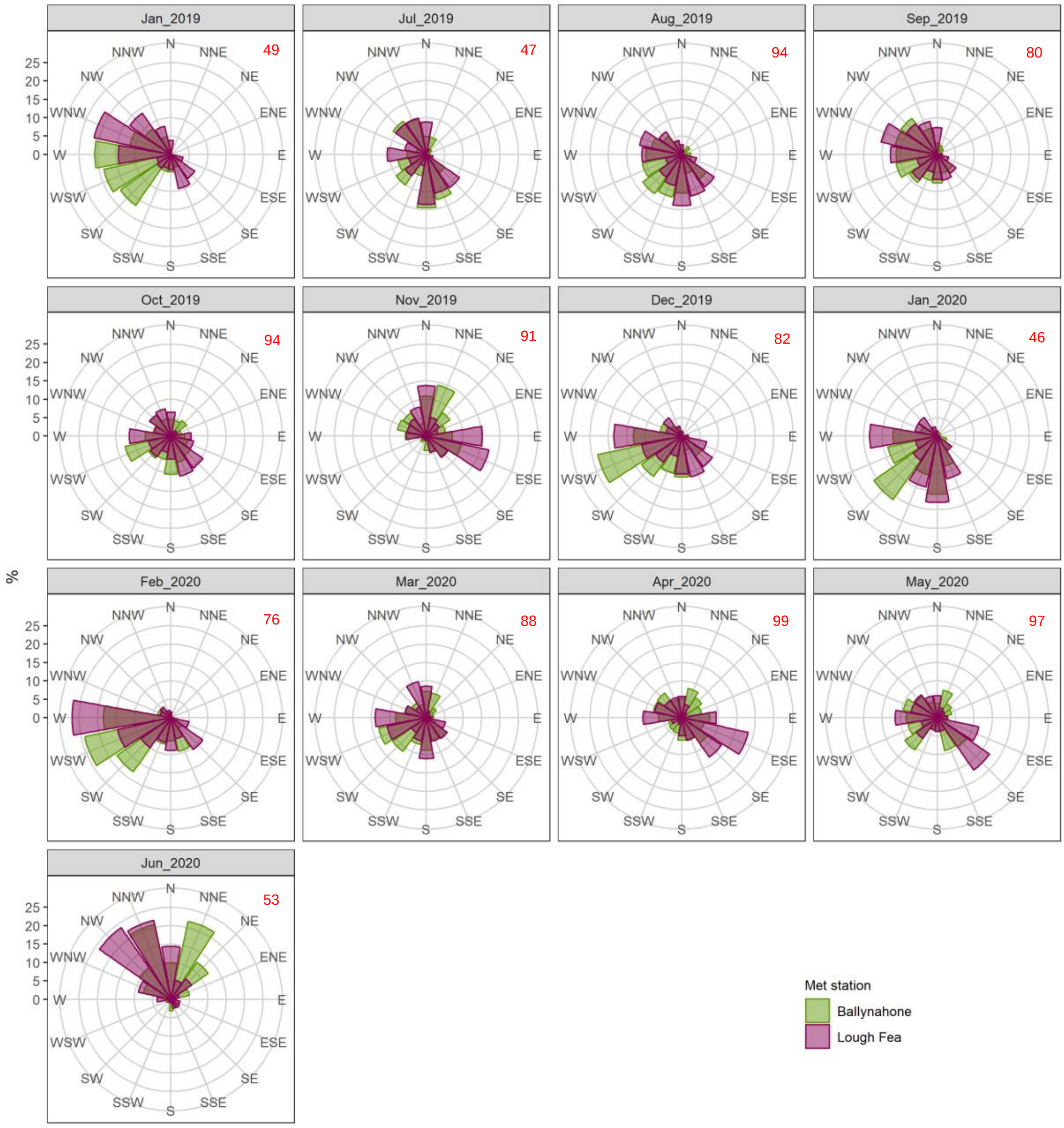


*Figure 4: Monthly wind roses for met stations at Ballynahone Bog and Lough Fea. Lough Fea data have been subset to show only wind direction data from dates where data are available from Ballynahone Bog for comparison. Number in red font indicates percentage of monthly data included in each month from both met stations.*

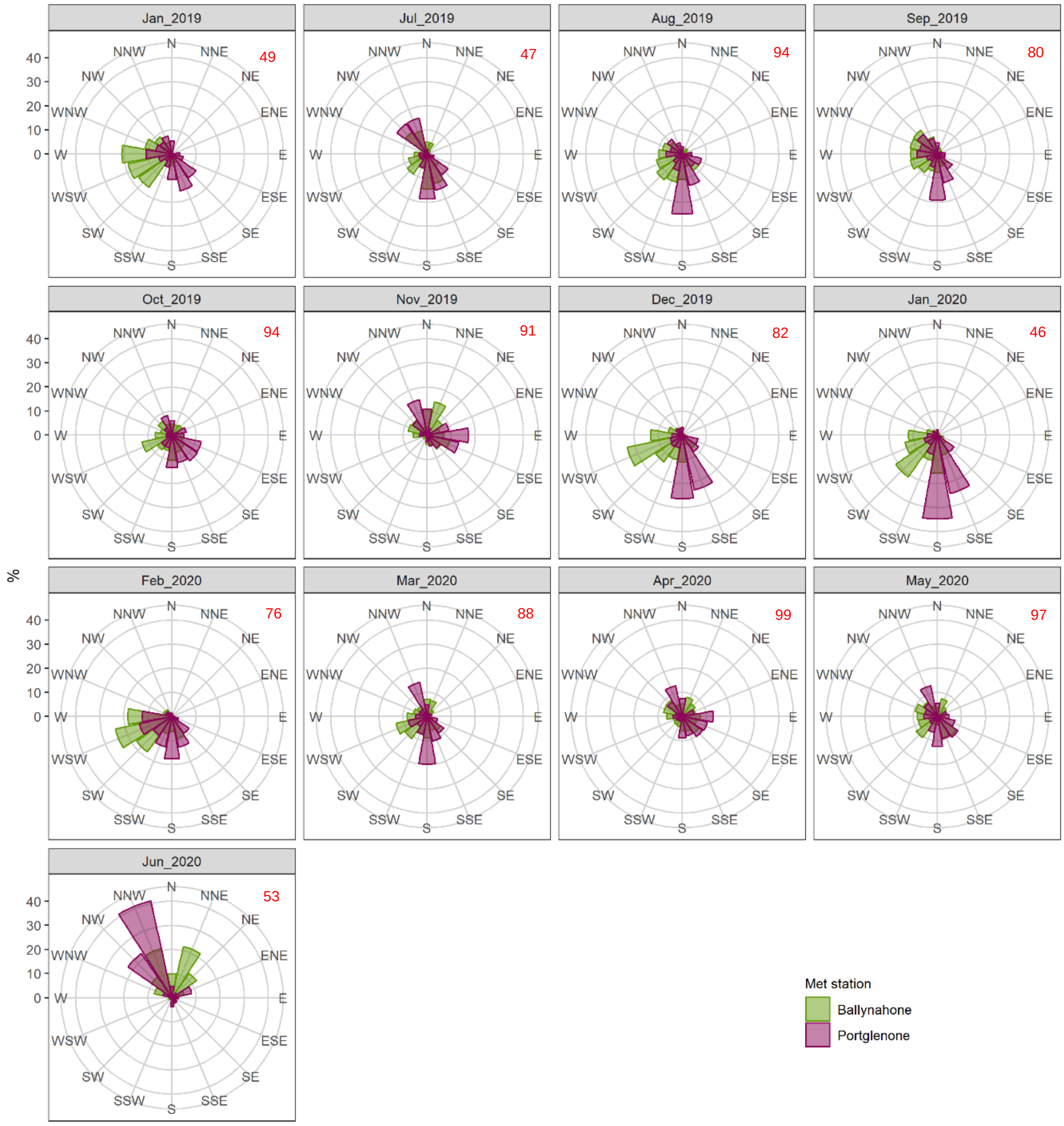


*Figure 5: Monthly wind roses for met stations at Ballynahone Bog and Portglenone. Portglenone data have been subset to show only wind direction on dates where data are available from Ballynahone Bog for comparison. Number in red font indicates percentage of monthly data included in each month from both met stations.*

Although the Portglenone met station is situated in an area that appears to be similar terrain to Ballynahone (Figure 2), the wind direction are fairly uncomparable to Ballynahone Bog and Lough Fea. Portglenone has a strong prevalence of Southerly winds (Figure 5). The air-flow surrounding the Portglenone site is likely influenced by local topography, i.e its close proximity to an elevated ridge on the east side of the met station (Figure 2) which may channel winds in a different direction. Portglenone therefore is likely to be unrepresentative of the winds experienced at Ballynahone Bog and would not make a reliable proxy for the Ballynahone Bog site.

## 2.3 Analysis of local wind patterns and their influence on $NH_3$ concentrations on the bog

As outlined above, wind data were not recorded on Ballynahone Bog for the period February to June 2019 (Figure 6). Near complete data has been collected for January to June 2020, however the SARS-Covid19 outbreak prevented sampler exchange during March 2020 due to movement restrictions. The ALPHA samplers set out at the start of March were therefore not collected until late April and these measurements represent a 2-month average (wind data coverage 88-99%, Figure 7). This spring period is key in terms of ammonia emissions due to land spreading of slurries and manures in the wider area.

The highest monthly $NH_3$ concentrations (>10 µg $NH_3$) for 2019 were recorded across several measurement sites in March and at all sites in April 2020 (>4 µg $NH_3$) (Figure 6 & 7). The March ammonia concentration peak seen in 2019 is likely to have been smoothed out in 2020 due to the ALPHA sampler being exposed to a longer than normal time period. However, the sampler is unlikely to have reached saturation point and can therefore be viewed as an accurate reflection of ammonia concentrations at the site over the two month period.

It is difficult to interpret the main emission sources contributing to the elevated concentrations during the peak landspreading months without suitable ammonia concentration data for March in both years. However the combined March and April 2020 wind data show similar contributions from all wind sectors rather than any prevailing direction. This may be an explanation of why all measurement sites recorded similar levels of ammonia concentrations (Figure 6 & 7). In general, ammonia concentrations are lower in 2020 compared to the previous year. The periods with aggregated ammonia data (due to SARS-Covid19) are not helpful for a full understanding of the role wind direction plays in the distribution of ammonia concentrations.

Data from the met station on Ballynahone Bog from October to December 2019 are reasonably complete (total monthly coverage of 82–94%), and these months show contrasting wind patterns between months (Figure 6). Ammonia measurements during these months also show similarly contrasting patterns in concentration values. These winter months correspond with the closed period (where landspreading is not permitted under NAP rules) and where lower concentrations are expected across the wider landscape.

$NH_3$ emissions during this period are likely to be related to nearby animal housing and manure storage sources. Site 8, which is furthest from possible emissions sources, remains relatively clean during these months, as do many of the wider landscape sites (Figure 6). In October and December 2019, concentrations of 4 - 7 µg $NH_3$ $m^{-3}$ were recorded at sites situated in the SW of the bog, with the prevailing SW wind direction passing over local emissions sources before reaching the bog.

N.B. Monthly met data are calculated for calendar months (e.g. 31 days in January), whereas monthly exposure periods for the measured $NH_3$ concentrations are generally calendar month +/- 5 days. This difference of a few days is not expected to change the wind rose profile for comparison with $NH_3$ data.

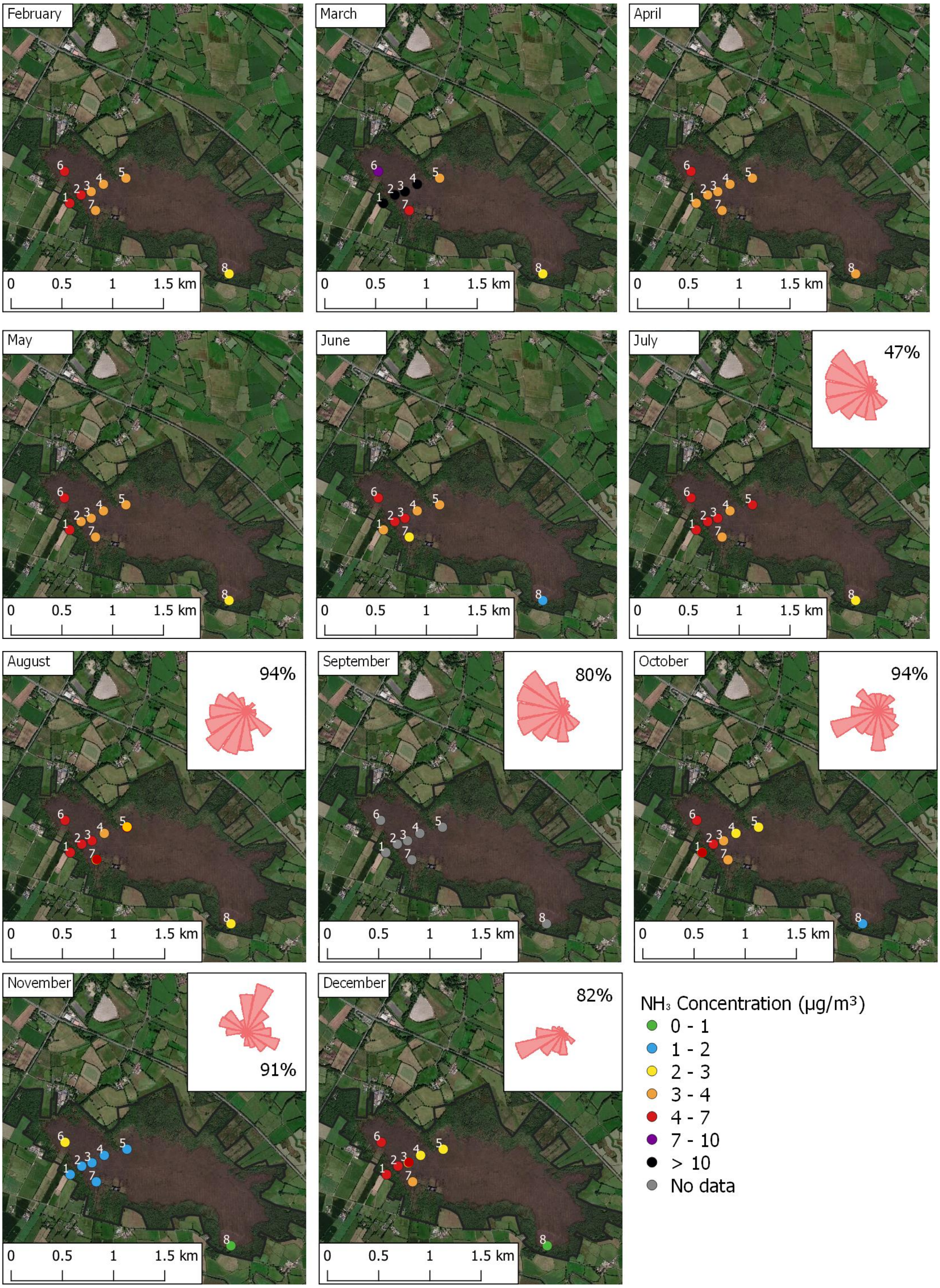


*Figure 6: Monthly 2019 $NH_3$ concentration at measurement sites on Ballynahone Bog, with wind roses for months with available data from the Ballynahone bog met station. Wind roses shown are derived from met data with data capture of between 47 - 94 %.*

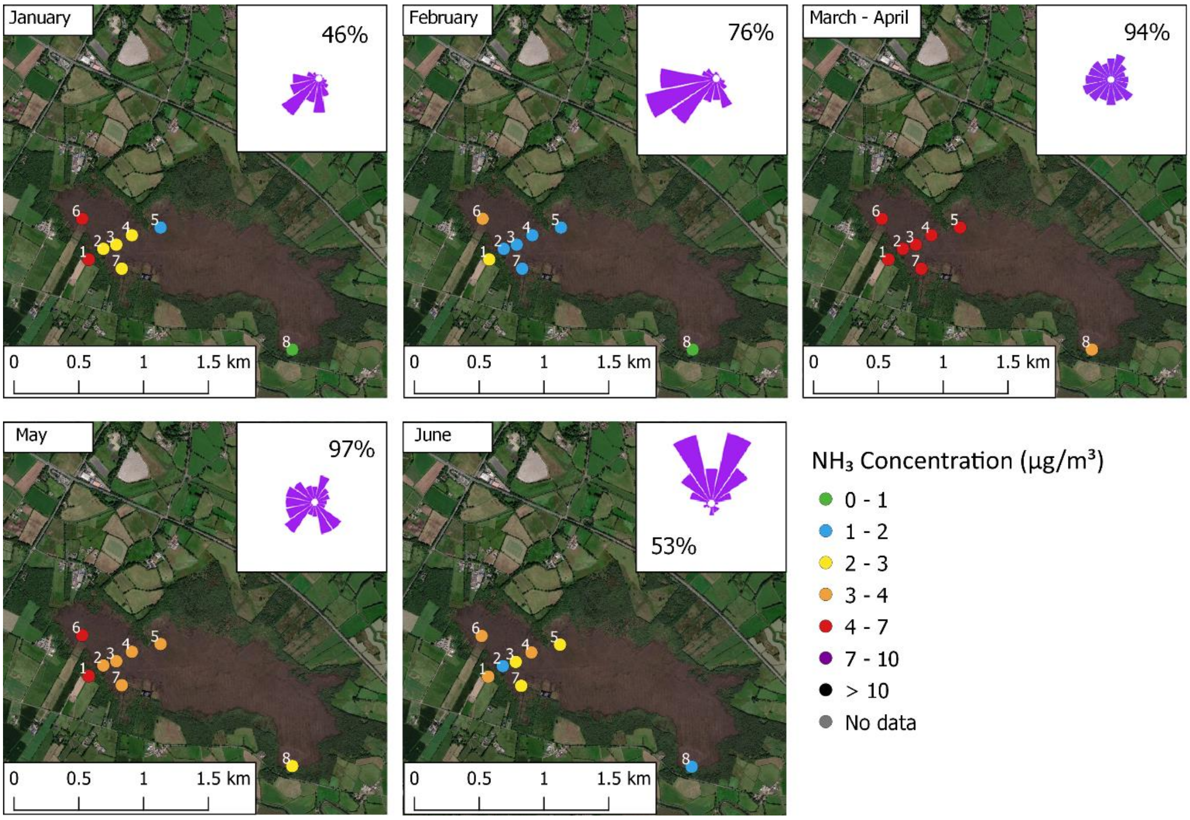


*Figure 7: Monthly 2020 $NH_3$ concentration at measurement sites on Ballynahone Bog, with wind roses for months with available data from the Ballynahone bog met station. Wind roses shown are derived from met data with monthly data capture of between 46 - 97%. A two-month average was taken across the March – April 2020, as samplers could not be exchanged at the end of March due to SARS-Covid19 travel restrictions.*

Ammonia concentration data have been collected by nine ALPHA samplers surrounding Ballynahone Bog from February 2019 to present (June 2020 for this reporting period, Figure 8 & 9). Near complete data has been collected for the year 2019 (February to December), however the SARS-Covid19 outbreak prevented sampler exchange during March and April 2020 due to movement restrictions. The ALPHA samplers exposed at the start of March were therefore not collected until late May and these measurements represent a 3-month average. Due to the lack of monthly data for this period it is therefore not possible to compare spring concentration trends between 2019 and 2020.

The ammonia monitoring network surrounding Ballynahone was established to better understand ammonia emission sources (and subsequent elevated concentrations and deposition) in the area surrounding the site. Ammonia concentrations of 4 to >10 µg $m^{-3}$ $NH_3$ were recorded at several measurement sites between February and May 2019, coinciding with local land spreading activity. Lower ammonia concentrations of 1 to 7 µg $m^{-3}$ $NH_3$ were recorded in November and December 2019 which aligns with the closed season, when no slurry spreading is permitted across Northern Ireland.

Of the measurements carried out so far in 2020 and reported here (Figure 9), peak ammonia concentrations were recorded in March, April and May (4 - 10 µg $NH_3$). Patterns in agricultural activity may have been affected by COVID-19 or may possibly be driven by differences in meteorology. When a 3 month average is compared for March to May for both years, the majority of concentrations across the landscape are lower in 2019 than 2020 (1 to 5 µg $NH_3$) apart from Sites 4, 6 and 9 which showed higher concentrations (6 to 10 µg $NH_3$). However, with the ammonia concentrations between March and May being a 3 month average it is difficult to determine the exact reasons and temporal patterns. For the month of February, comparisons can be made between the two years: February 2020 was a very wet month (Met Office 2020[2]) so farmers would have delayed slurry spreading and this is evident from the low concentrations across the landscape, compared with February 2019.

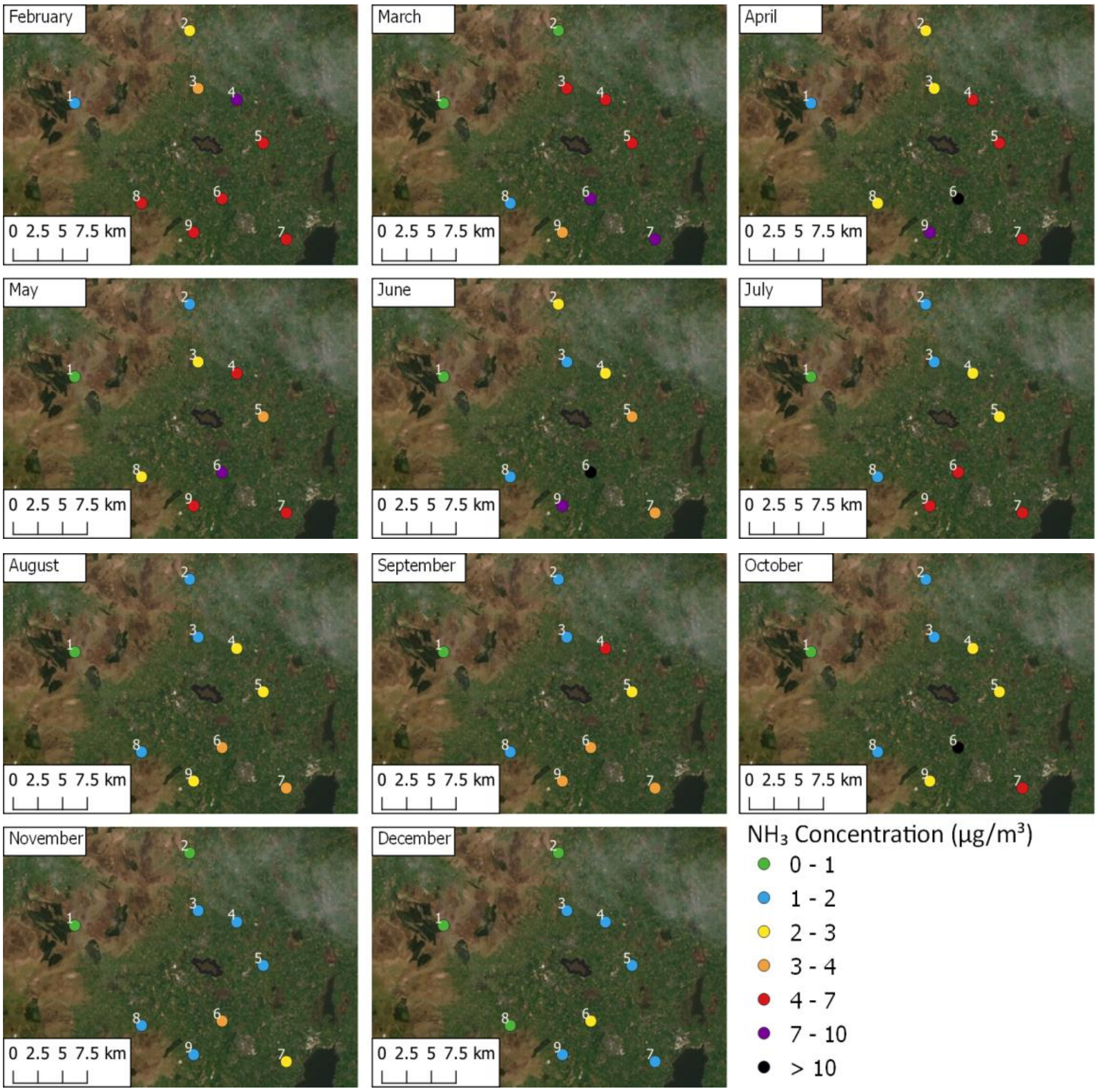


*Figure 8: Monthly $NH_3$ concentration at measurement sites around Ballynahone Bog in 2019.*

[2] https://catalogue.ceda.ac.uk/uuid/bbd6916225e7475514e17fdbf11141c1

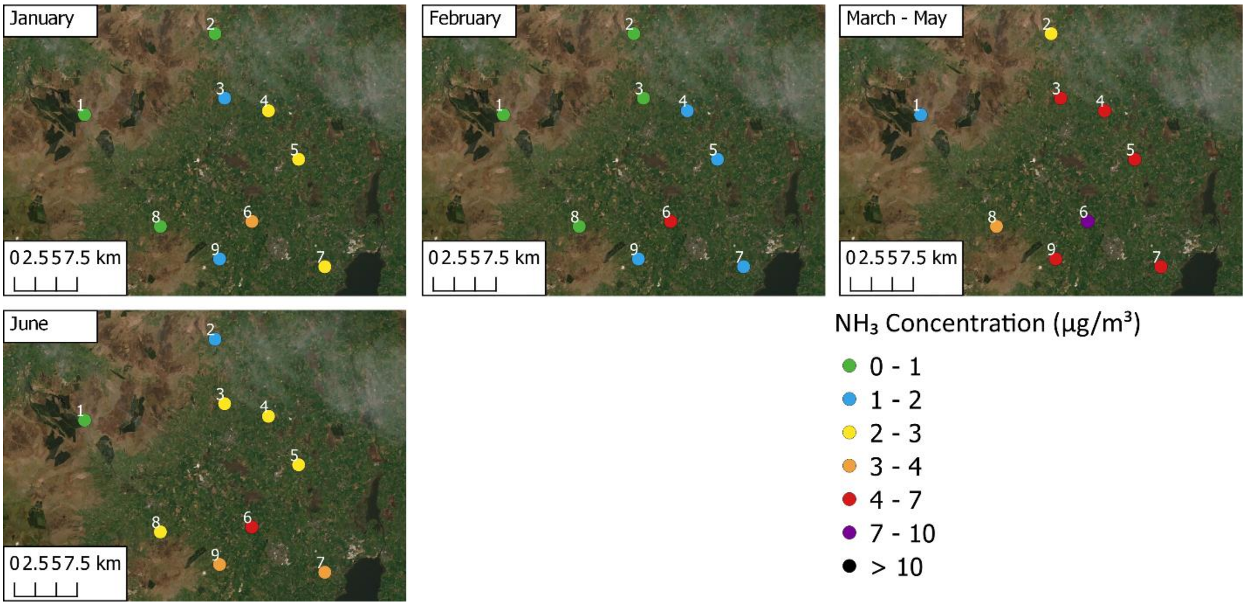


*Figure 9: Monthly $NH_3$ concentration at measurement sites around Ballynahone Bog in 2020. March, April and May data were combined as it was not possible to access the sites and exchange samplers due to SARS-Covid19 travel restrictions.*

# 3 Discussion and conclusions

Wind direction data can provide a valuable insight into inferring the sources of high ammonia concentrations measured at a site. Continued parallel monitoring of wind direction and $NH_3$ concentrations at the site will be useful to capture a whole cycle of relevant emission sources and events throughout a year as this was not possible due to the met station at Ballynahone Bog intermittently working and COVID-19 restrictions.

This annual cycle may highlight the importance of more diffuse sources, such as land spreading, across the wider area during the spring months. As neither Lough Fea nor Portglenone met stations are entirely suitable as a proxy for wind direction at Ballynahone Bog, having a reliable source of met data on site would be key to ensure accurate interpretation of concentration data. The project will benefit from the DAERA procured weather station to increase the reliability and accessibility of data, so that malfunctions can be remotely identified and quickly rectified.

Further work has explored whether Lough Fea (the more suitable of the nearby met stations) wind patterns could be used to fill in data gaps in wind data for the most recent years (2019-2020), for use in a local scale modelling task for the landscape surrounding the bog, and to generate multi-year time series of measurements at Ballynahone Bog dating back to September 2014. This is reported separately (Williams et al., in preparation). With the new met station operational since 1st October 2020 further analysis and interpretation of ammonia concentration patterns in combination with weather data will be carried out.

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