New Forest

Air Quality Ecological Mitigation Plan

Prepared on behalf of

New Forest District Council and New Forest National Park Authority

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Client:	New Forest District Council and New Forest National Park Authority
Contributors/Surveyors:	Ben Kite BSc (Hons) MSc CEcol PIEMA MCIEEM Andrew Cross BSc (Hons) MSc MCIEEM Neil Sanderson BSc (Hons) MSc Rebecca Brookbank BSc (Hons) PhD MCIEEM David Smith BSc (Hons) PhD MCIEEM Robert Souter BSc (Hons) PhD MCIEEM James Mitchell BSc
Report Prepared for Issue by:	Ben Kite ………………………………. Ben Kite BSc (Hons) MSc CEcol PIEMA MCIEEM
Report Approved for Issue by:	R. Brookbank ………………………………. Rebecca Brookbank BSc (Hons) PhD MCIEEM

Ecological Planning & Research Ltd
The Barn, Micheldever Station, Winchester, Hampshire SO21 3AR
Tel: 01962 794720 Fax: 01962 794721 email: info@epr.uk.com www.epr.uk.com

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1. INTRODUCTION

Context

1.1 Ecological Planning & Research Ltd (EPR) was commissioned in April 2018 to assist New Forest District Council (NFDC) and the New Forest National Park Authority (NFNPA) with an aspect of the Habitats Regulations Assessment (HRA) of their respective Local Plan Reviews.

1.2 HRA Reports prepared for the emerging NFDC Local Plan and NFNPA Local Plan Reviews (LUC, 2018) identified the need for more information on the effects of air pollution on Internationally designated nature conservation sites (The New Forest Special Area of Conservation (SAC), New Forest Special Protection Area (SPA) and New Forest Ramsar Site).

1.3 This requirement has arisen from the conclusions of a desktop study report on Air Quality Risks to Ecology produced for the NFDC and NFNPA by BSG Ecology (2018). This report reviewed the outputs of air quality modelling (Air Quality Consultants (AQC), 2018) carried out to inform the HRA of the Local Plan Reviews and provided advice on the risks to Internationally designated nature conservation sites resulting from traffic-related air pollution arising from development envisaged as coming forward under the two Local Plan Reviews, in combination with other planned development.

1.4 Full descriptions of the air quality modelling that has been carried out are detailed in the '*Air Quality Input for Habitats Regulations Assessment: New Forest* Report' (AQC, April 2018), and for brevity are not repeated at length here, except insofar as specific aspects of the modelling have particular implications for this current phase of work.

1.5 BSG's report reviewed the outputs of the AQC air quality modelling work and concluded that the Local Plans were unlikely to have a significant effect on the New Forest SAC / SPA and Ramsar when considered alone as a result of traffic related air pollution.

1.6 However, the report also noted that exceedances of the Critical Loads and Levels ('CLs') for certain pollutant types were predicted resulting from additional traffic generated by the Local Plans in combination with other sources, and that there was a degree of uncertainty pertaining to the likely significance of these in-combination effects, particularly in relation to ammonia (NB: this refers to ammonia as a gas, to which the assessment process applies a Critical Level). Further, the BSG Report identified a lack of site-specific information for the New Forest upon which to base firmer conclusions.

1.7 The BSG Report subsequently recommended that:

> *"The New Forest District Council and the New Forest National Park Authority undertake periodic vegetation monitoring to determine the current condition of sensitive vegetation and to identify any changes that occur during the life of the two Local Plans (measured at appropriate intervals). The monitoring would need to be complemented by a*

mitigation strategy that sets out actions that will be implemented if required…” [Paragraph 9.32]

1.8 As a result of the above conclusions, the HRAs of the two Local Plans (LUC, 2018) concluded:

> *“Implementation of the NFNPA Local Plan and NFDC Local Plan in isolation is not likely to have a significant effect on the New Forest SAC, SPA and Ramsar site.* ***In combination effects will result in exceedances for ammonia and acid deposition****, although exceedance of critical loads / levels is also predicted in the absence of the Local Plans. Advice published by APIS indicates that site-specific information on the effects of ammonia and acid deposition on vegetation is limited. The ecological assessment therefore* ***recommends that NFNPA and NFDC undertake periodic vegetation monitoring*** *to determine the current condition of sensitive vegetation and to identify any changes that occur during the life of the two Local Plans (measured at appropriate intervals). The monitoring would need to be* ***complemented by a mitigation strategy*** *that sets out actions that will be implemented if required. Habitat management measures that can be used to mitigate the impact of airborne pollutants are also summarised in the ecological assessment.”*

1.9 It is the above recommendations, and in particular the need to obtain primary field survey data to enable a better understanding of the effects of traffic related air pollution on New Forest habitats, that have led to EPR’s current commission that forms the basis of this report.

1.10 It should be noted that although the above text from the HRA Report (LUC, 2018) refers to acid deposition, paragraphs 8.47 to 8.50 and 9.24 to 9.25 of the BSG Report (2018) specifically consider acid deposition and note that the levels of acid deposition across the New Forest as a whole have declined markedly from historic levels, primarily due to large reductions in Sulphur Dioxide (SO_2) concentrations corresponding to improvements in industrial emissions driven by tougher regulation (SO_2 gas is in the majority of instances the principle contributor to acid deposition, but is not produced in any significant quantity by motorised vehicles).

1.11 Further, in their report, BSG note information from the Air Pollution Information System (APIS), that the contribution to acid deposition from nitrogen species (a weaker acidifying factor that is contributed towards by motorised vehicles), when considered alongside the reduced Sulphur contributions, falls within the ‘envelope of protection’ determined by the Critical Load Function (CLF) tool for dry and wet heathlands and broadleaf woodland.

1.12 Further to this, AQC note at paragraph 2.8 of their report that:

> *“The critical loads for nutrient nitrogen deposition are at least as stringent as those for acid nitrogen deposition (i.e. the critical load for acid deposition could not be exceeded unless the critical load for nutrient nitrogen deposition was also exceeded). This study has, therefore, focused on nutrient nitrogen deposition and not presented results for acid deposition.”*

1.13 Due to the above, AQC did not produce any specific modelling for acid deposition, and instead nutrient nitrogen deposition was used as a ‘proxy’ to determine areas that could potentially be affected by acid deposition. Notwithstanding therefore, the information provided by BSG Ecology that indicates that acid deposition from traffic is unlikely to be a problem, it is not possible to quantify levels of acid deposition from road traffic for the purposes of comparing those levels against field observations of vegetation.

1.14 Instead, as nutrient nitrogen deposition has been used as a proxy measure for nitrogen-related acid deposition, the approach taken by EPR has been to target fieldwork investigations toward those areas identified in the modelling as being subject to high levels of nutrient nitrogen deposition, and then to consider qualitatively the extent to which the effects observed (if any) may be related to either eutrophication or acidification as the two symptoms of pollutant deposition.

Response to the Brief and the Structure of this Report

1.15 To summarise the above, traffic-based air quality desktop assessment work for NFDC and the NFNPA has been unable to exclude the potential for in-combination effects (background growth plus local plan) on Internationally designated sites in the New Forest, and data limitations mean that it has not thus far been possible to conclude, by desktop work alone, whether the potential effects might be significant.

1.16 EPR were commissioned by NFDC and NFNPA to address the abovementioned information deficits, to inform the ongoing HRA of their emerging Local Plan Reviews.

1.17 The scope of work commissioned was as follows (condensed from the brief):

Task 1a: *Using the maps provided for a 2036 in-combination (background growth plus local plan), undertake a desk-based assessment on the identified sites located within the identified 200m buffer of the affected roads for Nitrogen oxides, Ammonia and Nitrogen Deposition to screen out those sensitive to air pollution. Consideration should be given to the habitat sensitivity to that emission type.*

Task 1b: *Undertake an agreed sample number of site visits for those areas that cannot be screened out via the desk-based study.*

Where there is uncertainty over the sensitivity of the feature in close proximity to a road affected by the plan or project, then a precautionary approach should be taken with an assumption made that the feature may be sensitive. For screening purposes the following considerations to the following should be given:

- *Consider whether the sensitive qualifying features of the site would be exposed to emissions.*
- *Consider the European Site's Conservation Objectives –can it be ascertained that, should the plan or project go ahead, there will be no adverse effect from it on the site's integrity so that the site's conservation objectives will not be undermined.*
- *Consider background pollution.*
- *Consider the designated site in its national context.*
- *Consider the best available evidence on small incremental impacts from nitrogen deposition.*
- *Consider the spatial scale and duration of the predicted impact and the ecological functionality of the affected area.*

- *Consider site survey information.*
- *Consider national, regional and local initiatives or measures which can be relied upon to reduce background levels at the site.*
- *Consider the imposition of additional mitigation measures to avoid an effect on integrity.*

Task 2: *Produce an air quality mitigation plan, to be subsequently agreed with Natural England with proposed costs and a mechanism for collecting contributions. The mitigation strategy is likely to include a number of measures including monitoring. The air quality mitigation strategy should set out clearly what measures are required to be* [implemented].

1.18 An inception meeting was held with NFDC, NFNPA and Natural England (NE) on 17 April 2018 to discuss the brief and agree an approach. Following this, a draft strategy was produced by EPR and circulated to the authorities and to NE for comment. These comments were subsequently responded to. Botanical field survey work under Task 1b was then begun on 11 May 2018.

1.19 This document presents the study methods and results, an analysis of those results and their interpretation, and an air quality mitigation plan for the New Forest International sites as required by Task 2.

1.20 The structure of the report is as follows:

- **Section 2** – Provides details of relevant policy and practice that forms important context to the understanding of this work;
- **Section 3 –** Details the methodology that has been used for this assessment, an in particular for the botanical fieldwork investigations that were undertaken;
- **Section 4 –** Outlines the key results gleaned from both the desktop and fieldwork investigations that have taken place, and provides an analysis of the data and an interpretation of their implications;
- **Section 5** – Provides a high-level overview of the recommended content of the proposed monitoring and mitigation package;
- **Section 6 –** Gives the detail of a recommended monitoring methodology;
- **Section 7 –** Outlines the key components of any mitigation strategy that would be brought to bear should ongoing recommended monitoring detect any negative effects resulting from traffic related air pollution;
- **Section 8 –** Outlines an estimate of the likely cost of the measures contained in Sections 6 and 7; and
- **Section 9 –** Gives overall conclusions and recommendations.

2. AIR POLLUTION: ECOLOGICAL IMPACTS AND CONTEXT

Introduction

2.1 This section frames the work that has been carried out, as presented in this report, in terms of current research and guidance.

Habitats Regulations Assessment (HRA)

2.2 Undertaking the HRAs of the emerging NFDC and NFNPA Local Plans sits outside of the remit of this commission (it is the responsibility of the plan-making authorities as competent authorities under the Conservation of Habitats and Species Regulations 2017, advised both by Natural England as the statutory nature conservation advisor and Land Use Consultants as the authorities' HRA consultant). However, as this work is ultimately intended to inform the HRAs of the Local Plans, it is important that it sets out to obtain sufficient information to enable the tests of the Habitats Regulations to be approached.

2.3 As such, the following key guidance on undertaking HRA has been taken into consideration in formulating the approach to this work:

- '*Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites*' (EC, 2001);
- The European Commission's '*Managing Natura 2000*' document (2000) that provides guidance on some of the key concepts enshrined in Article 6 of the Habitats Directive);
- The *'Communication from the Commission on the Precautionary Principle*' (2000) which provides guidance on the correct application of the precautionary principle, stating that it should be applied with proportionality and should not aim at zero risk;
- Circular 06/05 *'Biodiversity and Geological Conservation – Statutory Obligations and Their Impact Within the Planning System'*;
- '*Planning for the Protection of European Sites*' (DCLG, 2006); and
- PINS NOTE 05/2018 *'Consideration of avoidance and reduction measures in Habitats Regulations Assessment: People over Wind, Peter Sweetman v Coillte Teoranta'* (Planning Inspectorate 9 May 2018).

Air Quality Research

National Air Quality Context

2.4 At the National Level, the UK Government has produced a '*UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations'* (July 2017) with a view to reduce traffic-related Nitrogen Dioxide (NO_2) roadside concentrations across the UK in the fastest possible time period. The document sets out various measures to do this, such as funding for retrofitting clean technology to public transport vehicles and for promoting walking and cycling. However, one very important measure is that it proposed to ban the sale of all new conventional petrol and diesel cars and vans by 2040.

2.5 The proposed 2040 ban on the sale of conventional petrol and diesel cars and vans is a particularly important measure with potentially significant implications for this report. If implemented as proposed, it is likely to lead to very significant, but gradual (due to the time it takes existing vehicles to reach the end of their service lives and be retired) declines in NOx emissions from traffic along roads throughout the New Forest. As ecologists, it is not within EPR's professional competence to quantify the predicted length of time it would take for NOx emissions from traffic to decline following the implementation of the ban.

2.6 Notwithstanding this, the implications of the proposed ban are that it would place a time limit on the extent to which habitats within the New Forest were subject to the elevated levels of traffic-related nitrogen pollution associated with both existing development and development coming forward as part of the Local Plans. This would be in addition to other anticipated future improvements such as the increased use of electric vehicles etc. This is an important consideration, since the majority of effects on vegetation arising from traffic-related air pollution, and the most significant (except in the most grossly polluted locations), occur due to chronic long-term pollution gradually driving changes in vegetation composition through changes in soil chemistry affected over time. Any significant drop-off in NOx and nitrogen deposition associated with the proposed 2040 ban would therefore be likely to define the temporal end-point of any traffic-related factors driving any such harmful changes, and potentially mark the start of an opportunity for habitat recovery.

Trends in Traffic-Related Nitrogen Air Pollution

2.7 Notwithstanding the well-documented and extensive reductions in SO_2 pollution and related acid deposition across the UK alluded to above, declines in NOx and related nitrogen deposition pollution anticipated to result from increased regulation and tougher emission standards have been slower to manifest than hoped, in part due to the well-publicised controversies regarding diesel vehicle emissions. However, a summary of 'real-world' monitoring studies, compiled by Air Quality Consultants Ltd in 2016[1] determined that diesel vehicles manufactured under the current European emission standard, Euro 6 (introduced from 2014), produce significantly less NOx than the preceding Euro 5 vehicles (introduced from 2009):

> *"Euro 6 vehicles are, on average, performing significantly better than earlier vehicles. For example, Euro 6 vehicles appear to be achieving reductions of between 50% and 70% when compared with Euro 5 vehicle."*

2.8 The above trend has been discussed in AQC's Report for NFDC and NFNPA (2018), with the ultimate conclusion reached that future concentrations of NOx are expected to fall, albeit not as rapidly as historically predicted (paragraph 3.9 and 3.18). The UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations also acknowledges past declines as a result of these factors and sets out the expectation for this improvement to continue.

2.9 Separately from the consideration of airborne NOx concentrations however, is the need to consider the proportion of total nitrogen emitted from vehicles as ammonia. This is important because, whilst oxidised forms of nitrogen may themselves contribute toward impacts on

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[1] Marner, B. (2016) *Emissions of nitrogen oxides from modern diesel vehicles*. Air Quality Consultants Ltd.

vegetation, reduced forms of nitrogen such as ammonia, typically more often associated with agricultural sources, can act as fertilisers and drive eutrophication of habitats and thus affect changes in vegetation composition.

2.10 As explained in paragraph 3.19 of AQC's Report, one of the measures taken to reduce emissions of NOx (which can be harmful both to ecological receptors and human health) is to fit new vehicles with Selective Catalytic Reduction (SCR) technology. This technology effectively converts some of the NOx that might otherwise be emitted and converts it into ammonia.

2.11 The Air Quality section of the Design Manual for Roads and Bridges (DMRB - Highways England, 2007), Annex F Assessment of Designated Sites, states that:

> *"ammonia emissions from road vehicles (from petrol-driven vehicles fitted with catalytic converters and heavy duty vehicles fitted with selective catalytic reduction), although small in a national context, can lead to significant additional deposition of nitrogen to vegetation in the immediate vicinity of roads (typically within 10m)."*

2.12 It is possible therefore, that one of the side effects of attempting to reduce NOx concentrations from traffic will be an increase in the deposition of ammonia, notwithstanding the potential effect of the proposed future ban on conventional petrol and diesel cars and vans. AQC's Report (2018) acknowledges this possibility (para 3.19) and notes the consequent uncertainty inherent in any attempt to model future traffic related ammonia emissions. The approach that AQC have taken therefore, is to assume a realistic worst-case scenario, and it is the outputs from this modelling that has been considered by EPR as part of this study.

Critical Loads and Levels

2.13 The science behind Critical Loads and Levels (collectively referred to herein as CLs for brevity) is set out at length in the BSG Ecology (2018) and AQC (2018) reports and is not therefore repeated in detail here. However, in summary, CLs are the common measure of environmental sensitivity to air quality change (also referred to within guidance as the 'environmental standard'). This is a defined as a:

> *"quantitative estimate of exposure to one or more pollutants below which significant harmful effects on sensitive elements of the environment do not occur according to present knowledge*"[2].

2.14 The critical load for nitrogen deposition on habitats has a range, with lower and upper critical load values provided to reflect variations in habitat responses under differing environmental conditions, such as precipitation level, height of the water table and intensity of habitat management, as well as geographical locations across Europe. Notwithstanding the precautionary use of lower critical load values in air quality assessment, APIS advises that upper critical loads are applicable to systems with a high water table, high precipitation and where sod cutting has been practised (as opposed to lower intensity management) –these conditions expedite removal of nitrogen from the system.

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2 https://www.unece.org/env/lrtap/workinggroups/wge/definitions.html

2.15 The exceedance of a critical load or level is not a quantitative estimate of damage to the environment; it indicates the potential for damage. More detailed assessment is required to understand whether significant damage to a designated site is likely or is actually occurring, and this assessment is informed by a number of factors such as background conditions, the area of habitat within which exceedance is predicted to occur, whether there are qualifying features present within that exceedance area, and whether those qualifying features are sensitive to the air pollution pathways concerned.

Air Quality Research Pertaining to Designated Nature Conservation Sites

2.16 Current research into air quality impacts on International sites, including as a result of road traffic, is addressed in the following relevant publications, and these have been referred to for this study since collectively they represent the most current evidence base:

International sites – air quality impacts from roads:

- Smithers *et al.* [AKA Ricardo-AEA Ltd] (2016a) *The ecological effects of air pollution from road transport: an updated review.* Natural England Commissioned Report NECR199;
- Smithers *et al.* (2016b) *Potential risk of impacts of nitrogen oxides from road traffic on designated nature conservation sites*. Natural England Commissioned Report NECR200;

Which was an update of:

- Bignall *et al.* (2004) *The ecological effects of diffuse air pollution from road transport.* English Nature Research Report 580;

International sites – air quality impacts in general and mitigation:

- Caporn *et al*. (2016) *Assessing the effects of small increments of atmospheric nitrogen deposition (above the critical load) on semi-natural habitats of conservation importance*. Natural England Commissioned Reports, Number 210;
- Dragosits *et al*. (2015) *Identification of Potential "Remedies" for Air Pollution (nitrogen) Impacts on Designated Sites (RAPIDS)*. Centre for Ecology & Hydrology (CEH);
- Jones *et al*. (2016) *A decision framework to attribute atmospheric nitrogen deposition as a threat to or cause of unfavourable habitat condition on protected sites*. *JNCC Report No. 579*. JNCC, Peterborough;
- Smits & Bal (2012) *Recovery strategies for nitrogen-sensitive habitats: Ecological underpinnings of the Programme Approach to Nitrogen (PAN)*. Alterra Wagening UR and Natura 2000 Programme Directorate of the Ministry of Economic Affairs, Agriculture and Innovation;
- Stevens *et al.* (2013) *Review of the effectiveness of on-site habitat management to reduce atmospheric nitrogen deposition impacts on terrestrial habitats*. CCW Science Series Report No: 1037 (part A), CCW, Bangor;
- Whitfield & McIntosh (2014) *Nitrogen Deposition and the Nature Directives: Impacts and Responses: Our Shared Experiences*. JNCC Report 521;

International sites – HRA:

- Chapman & Tyldesley (2016) *Small-scale effects: How the scale of effects has been considered in respect of plans and projects affecting European sites - a review of authoritative decisions*. Natural England Commissioned Reports, Number 205;

International sites – policy:

- GOV.UK (2015) *Atmospheric Nitrogen Theme Plan. Developing a strategic approach for England's Natura 2000 sites*;

Ecosystems – policy:

- DEFRA/DoT (2017) *UK plan for tackling roadside nitrogen dioxide concentrations;* and
- DCLG (2014) *Planning Policy Guidance: Air Quality*.

2.17 The work by Smithers *et al*. (2016) listed above included information on mitigating impacts on habitats arising from air pollution. Work is also being undertaken following Jones *et al*. (2016) to attribute site condition to air pollution as part of Common Standards Monitoring (CSM) of Sites of Special Scientific Interest (SSSI). CSM is currently not effective at collecting data on air pollution effects on vegetation, but work in ongoing to address this, and has been taken into account as part of this study.

Guidance on Potential Mechanisms for Mitigation Delivery

Site Nitrogen Action Plans (SNAPs)

2.18 Site Nitrogen Action Plans (SNAPs) stem from the Government's '*Atmospheric Nitrogen Theme Plan'* (GOV.UK, 2015).

2.19 The New Forest SAC/SPA Site Improvement Plan (SIP) identifies '*air pollution: impact of atmospheric nitrogen deposition*' as a priority issue. The proposed measure to address the issue is to '*control and reduce impacts of atmospheric nitrogen deposition*'.

2.20 The issue is further described as:

> "*Air pollution impacts on vegetation diversity. Aerial deposits of nitrogen may exceed the threshold limits above which the quality and character of vegetation begins to be altered and adversely impacted. This could potentially lead to a loss or change of habitat type which in turn will impact on species reliant on that habitat*."

2.21 The mechanism for tackling the action is stated as '*control, reduce and ameliorate atmospheric nitrogen impacts*' through a '*Site Nitrogen Action Plan (SNAP)*'.

2.22 The *Atmospheric Nitrogen Theme Plan* (GOV.UK, 2015) report states that:

> "*Although nitrogen emissions have been significantly reduced over the past decades, atmospheric nitrogen deposition is likely to remain above critical loads for many sites in the foreseeable future. Nitrogen deposition on protected sites comes both from long*

distance sources and from local diffuse and point sources. Three interrelated approaches are needed to achieve the long term targets along an achievable trajectory:

- *National and international measures which reduce the background deposition,*
- *Locally targeted measures that reduce nitrogen emissions close to protected sites, or that intercept deposition to the site,*
- *Habitat restoration measures that mitigate the impact of historic and on-going deposition."*

2.23 The theme plan proposes to trial the development of SNAPs to integrate these approaches at a site level, as a remedy for affected sites. SNAPs would document:

- The current status of the site in terms of nitrogen deposition and attribution of this nitrogen to identify the most significant sources;
- The expected future decline in background deposition at the site as a result of existing national and international measures;
- Coordinated locally targeted measures to reduce the contribution of local sources where feasible and appropriate; and
- Habitat restoration and management measures that mitigate the impact of atmospheric nitrogen.

2.24 The intention is that SNAPs would demonstrate what appropriate measures are in place to secure the integrity of the Natura 2000 sites and would coordinate possible future local measures.

2.25 Following consultation, NE provided a *'Quick Guide to SNAPs',* which has also been taken into account.

RAPIDS

2.26 RAPIDS *('Identification of potential "Remedies" for Air Pollution (nitrogen) Impacts on Designated Sites'*) (Dragostis *et al*. 2015) was a Defra project led by CEH undertaken to support the Improvement Programme for England's Natura 2000 Sites (IPENS) and the resultant Site Improvement Plans (SIPS). Some of the key principles that it outlines have been taken into consideration.

2.27 The RAPIDs project considers a wide range of sources of pollution:

> *"The main sources of atmospheric N deposition are nitrogen oxides (NOx) from vehicles, industry and electricity generation and ammonia (NH3), mainly from agricultural sources. The range of sources affecting designated sites was summarised into five key scenarios, which were generated in order to develop and illustrate a generic framework to target mitigation measures:*
>
> *1. Lowland agriculture (many diffuse sources)*
>
> *2. Agricultural point source(s)*

3. Non-agricultural (point) source(s)

4. Roads

5. Remote (upland) sites affected by long-range N input"

2.29 The project focused on impacts and remedies for designated conservation sites, especially Natura 2000 sites. Evidence was drawn together to develop a framework for identifying key nitrogen related threats at individual sites as a basis to target mitigation options in the context of potential legislative, voluntary and financial instruments.

2.28 For reducing the impact of emissions from major roads near designated sites, remedies include improved traffic management (e.g. optimising traffic flows, re-routing of traffic, traffic charging schemes), physical measures such as roadside barriers (with catalytic surfaces and/or to disperse NOx to lower atmospheric concentrations), and/or trees fulfilling a similar role.

2.29 The study also provided some useful information pertaining to the timescales within which certain mitigation option may be expected to yield results:

> *"For road transport, emission reductions are mostly derived from technological advances which typically take 5 -10 years to filter through the fleet. Acceleration may be possible through legislation (e.g. London Congestion Charge). Landscape-scale measures (e.g. low emission zones around sites) could provide immediate benefits, while tree belts need 10-20 years of growth to become fully effective.*
>
> *Timescales for recovery of ecosystems depend on the receptor, the decline in N input and the amount of N already accumulated. First signs of improvement are likely within 4 years (especially for epiphytes), although substantial recovery may take decades and systems may not return to pre-impact states. The speed and nature of the recovery may be affected by on-site restoration measures."*

2.30 The study states that evidence for success can take various forms, and be measured in terms of:

> *"Reduced emissions through uptake of measures quantified/verified by resulting changes in N concentrations/deposition (requiring atmospheric monitoring and/or modelling of change).*
>
> *Local habitat-based biological/biogeochemical indicators, such as floristic change, tissue N content, plant-available N in soils, nitrate concentrations in aquatic habitats. Such evidence for success needs to be considered together with timescales for recovery of the habitats and species."*

2.31 In terms of monitoring, the study states:

> *"A key requirement for demonstrating success at a site level is baseline monitoring (especially for N concentration and deposition rates, and the more responsive indicators) before measures are implemented, and a consistent methodology for detecting change over time…..*

For designated sites, the current Common Standards Monitoring is not designed to detect or attribute gradual trends in species composition change, but could be augmented by the inclusion of permanent monitoring quadrats. Other repeatable surveys at sites with historical data could provide alternatives. The 'biomonitoring chain' concept links key indicators from emission to deposition with species responses for evidence of success."

2.32 A draft framework was developed under RAPIDS, guiding the user through:

- Identifying major atmospheric N sources for each designated site (with national & local scale data);
- Selecting suitable measures from for each site, based on local conditions;
- Checking local availability of spatially targeted instruments (e.g. agri-environment schemes); and
- Detailed assessment of measures or, for remote sites, referral for higher-level actions.

2.33 The draft framework was piloted for UK SACs and A/SSSIs and illustrated for several case studies. It showed that there is no single 'one size fits all' solution, and spatial considerations of relevant N sources at sites are needed for cost-effective mitigation.

3. STRATEGY & METHODOLOGY: FIELDWORK AND DESKTOP STUDY

Introduction

3.1 This section of the report details the rationale behind the fieldwork and desktop study that was carried out to investigate further the vulnerability of New Forest habitats to traffic-related air pollution associated with the Local Plans. It outlines the key considerations that have informed the approach taken, sets out the overarching strategy, and provides the detailed methodology.

Qualifying Features for Investigation

3.2 The habitats that form the focus of this work are those habitats which form the qualifying features of the New Forest SAC listed under Annex 1 of the Habitats Directive (92/43/EEC), as follows:

- **3110** Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae);
- **3130** Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletalia uniflorae and/or of the Isoëto-Nanojuncetea;
- **4010** Northern Atlantic wet heaths with *Erica tetralix;*
- **4030** European dry heaths;
- **6410** Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae);
- **7150** Depressions on peat substrates of the *Rhynchosporion;*
- **9120** Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion);
- **9130** Asperulo-Fagetum Beech forests;
- **9190** Old acidophilous Oak woods with *Quercus robur* on sandy plains;
- **91D0** Bog Woodland; and
- **91E0** Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae).

3.3 Although the New Forest is also designated as an SAC for the presence of populations of certain animal species (Southern Damselfly, Stag Beetle and Great Crested Newt), these are not themselves directly vulnerable to impacts from traffic related air pollution at the levels contemplated. Rather, they could be indirectly affected by long-term changes to their habitats driven by air pollution. In this respect, to the extent that their habitats may be vulnerable, potential effects on all three species are adequately covered by consideration of the Annex 1 habitats that they live in. Where the species could occur outside of the Annex 1 habitats, such occurrences are very unlikely to coincide in any significant way with areas of air pollution exceedance associated with the Local Plans such that the assessment would omit important detail. For example, the Southern Damselfly is known to occur along the Crockford Stream and

Mill Lawn Brook – the former is located away from predicted exceedance areas, and the latter is bisected only once (by the A35) for a very short distance, and in that case the adjacent habitats include SAC habitats (heathlands and woodlands) that will be subject to consideration and which have a better evidence base that can be exploited to investigate potential effects.

3.4 Similarly, the New Forest is also designated as an SPA for supporting Internationally important populations of bird listed on Annex 1 of the Birds Directive (2009/147/EC) including: Dartford Warbler, Honey Buzzard, Nightjar, Woodlark and Hen Harrier. Potential effects on these species are adequately covered by proxy as a result of the consideration of the SAC habitats that support them.

3.5 Finally, the Ramsar designation of the New Forest overlaps sufficiently with the SAC designation that it too can be assessed 'by proxy' in the way proposed. Where the Ramsar qualifying features diverge from the SAC they are either unlikely to be vulnerable to air pollution, or are otherwise reliant on SAC habitats (for example in the case of the invertebrate assemblages).

Potential Changes in Air Quality and Sensitivity of Annex 1 Habitats to those Changes

3.6 The Annex 1 habitats of the SAC are sensitive to changes in certain chemicals associated with traffic. For this study, those chemicals are concentrations of NO_X, concentrations of Ammonia (NH_3) and the deposition of nitrogen (recorded in total).

3.7 The relevant critical levels and loads for the Annex 1 habitats for each pollutant type are detailed in **Appendix 1**, along with notes explaining the approach taken to each regarding which part of the Critical Load range should be used.

Constraints Presented to the Fieldwork Investigations

Uncontrolled Variables

3.8 As can be seen from the list above, the important Annex 1 habitats that form qualifying features of the SAC are many and varied, and they can occur in many different locations and circumstances and be subject to a multitude of prevailing variables such as: topography, hydrology, management, grazing pressure, pH, soil conditions, geology or localised climatic conditions.

3.9 The time constraints for this commission mean that it will not be possible to collect soil or plant material samples for laboratory testing to determine nutrient status.

3.10 Any of these factors and variables could have the potential to act as confounding factors that might serve either to mask the effects of air pollution, or otherwise to imitate them, unless adequately controlled as part of any investigation.

3.11 In short, if two examples of the same Annex 1 habitat type in different locations exhibit differences in vegetation composition, it will be very hard to attribute those changes to air pollution rather than other influences, in the absence of very detailed information that cannot be collected within the timescales available for this commission.

3.12 To avoid type 1 and type 2 statistical errors therefore (explained further at paragraph 4.15 below) that could result in observed changes in vegetation being wrongly attributed to air pollution (or changes that were due to air pollution being wrongly attributed to other factors), a key challenge of the survey strategy was to identify the key prevailing variables at prospective sample locations and attempt to control for their potential to affect the survey results.

3.13 In practice, the main way that this was achieved was to choose a survey location where sufficient data over a sufficiently large enough area of habitat could be gathered in broadly similar prevailing conditions, to reduce the prospect for uncontrolled variables to influence results, and to enable any trends observed to be supported by sufficient evidence in terms of statistical validity. The aim was to minimise the influence of variables other than air pollution on the results obtained, so that any trends observed were more likely to be rightfully attributed to changes in air pollution, and where this was not possible, to obtain sufficient information about uncontrolled variables to enable their likely influence on results to be gauged.

3.14 In order to achieve the above, a survey location was chosen adjacent to the A31 in the north of the New Forest, where Annex 1 heathland habitats occur on a largely flat plateau, where information about management could be obtained and where areas subject to survey would be subject to less variance.

Lack of Detailed Habitat Mapping

3.15 A further challenge to the survey planning was that no current and detailed National Vegetation Classification (NVC) mapping is known to exist for the majority of the New Forest, and the existing habitat mapping (Broad Habitat Type and Priority Habitat Type mapping) obtained from the Hampshire Biodiversity Information Centre (HBIC) is not sufficiently detailed to enable individual areas of most types of Annex 1 habitat to be identified. The habitat categories included in the HBIC data are also relatively broad-scale in that they are summaries of the main habitat type within a chosen polygon. The variation of vegetation within a habitat polygon could be considerable and include one or more vegetation types.

3.16 The only existing vegetation/habitat dataset providing information on presence of habitats in the road corridor is that provided by HBIC. This dataset, whilst useful, was used and/or interpreted with caution for a number of reasons, some of which are listed below:

- The dataset does not explicitly label any polygons as Annex 1 Habitat;
- There is very little NVC information;
- The Survey Data is of variable age, with some going back to 1996. Some of the work is based on aerial photography interpretation, other is field work;
- A range of survey types have been used, with little information available for some of them as to the survey criteria;
- The polygons labelled as the 'Dry Heaths' are often composed of a number of habitats (i.e. a mosaic, which is typical of heathland landscapes); and
- The data for each polygon can be somewhat ambiguous: for example, '*Probably is the habitat but some uncertainty*'.

3.17 The dataset does however remain of considerable value for indicating where Annex 1 habitat **could** occur in 2018 and this has been used to identify where Lowland Dry and Wet Heath occur adjacent to the New Forest roads.

3.18 As an example, the habitat 7150 'Depressions on peat substrates of the *Rhynchosporion'* is a highly localised habitat that occurs at the margins of wet heaths and bogs. It is not itself mapped in any of the HBIC layers. Consequently, with the exception of habitat types captured in the available mapping (such as dry heaths, wet heaths and various woodland types) it was necessary to guess where other habitat types may occur based on aerial imagery and topography, and it was not possible to be certain that they would be present prior to actually visiting site to look for them.

The Need for Detailed Site-Specific Information

3.19 A further complication was the need to understand how typical vegetation types are likely to respond to levels of pollution in exceedance of the CLs. Some generic information for broad vegetation and habitat types is available (e.g. that provided by APIS), however very little information is currently available pertaining to the specific observed responses of New Forest habitats to traffic related air pollution. This is important because similar habitat types may respond very differently in different locations depending on the other prevailing variables mentioned above.

3.20 Information presented in English Nature Research Report (ENRR) 580 *'The ecological effects of diffuse air pollution from road transport'* (Bignall *et al.*, 2004) and the Natural England Commissioned Report NECR199 '*The ecological effects of air pollution from road transport: an updated review'* (Smithers *et al.*, 2016) have informed the approach taken in terms of the broad nature of impacts that are to be expected resulting from air pollution.

3.21 In terms of information that is specific to the New Forest, the most directly relevant source of information is a paper published by Angold in 1997. This work involved sampling vegetation on a series of transects perpendicular to the road edge, and looking for correlations between changes in vegetation composition and distance from the road edge. However, EPR commissioned a review of this work in 2003 by the highly experienced New Forest Ecologist Neil Sanderson (**Appendix 2**). This review flagged up some significant shortcomings in the work that was done by Angold – specifically, that effects on vegetation from management activities such as burning and grazing had not been taken into account. This is discussed further below.

Survey Season

3.22 The time available under the commission for carrying out fieldwork was effectively limited to May 2018. This is a good time of year to identify species associated with acid grasslands and heathlands, but less favourable for some species associated with wetland vegetation communities (those that could be relevant to some of the more localised Annex 1 habitat types).

Response to the Constraints and The Overarching Survey and Assessment Strategy

Location and Spatial Extent of Survey: Consideration of Air Pollution Modelling

Location of Surveys

3.23 Clearly, if a survey location is to detect signs of vegetation damage form air pollution, it must be located in an area in which air pollution is currently at levels where CLs are being exceeded. Conversely, any control site used to yield data on unpolluted habitats for the purposes of providing a comparison must be largely free of air pollution.

3.24 Further, any areas in which it may be proposed to carry out future monitoring to detect any vegetation changes being driven by air pollution must be forecast to exceed their CLs in the future.

3.25 To identify such areas and inform the strategy, reference was made to Air Quality modelling by AQC (2018) which has identified locations where the:

- Levels of air pollution are currently (modelled year of 2015) in exceedance of the CLs for different habitat and pollutant types (shown on **Maps 3.1 to 3.4**); and

- Areas where the cumulation of all air pollution sources (the 'Predicted Environmental Concentration' or PEC) are predicted to be above CLs in 2036, and where development associated with the Local Plans is anticipated to make a material (>1% of CL) contribution. Background information on Air Quality collated by APIS has also been taken into account.

3.26 Data from APIS and modelling work from AQC show existing levels of these pollutants. AQC have modelled changes to these for 2026 and 2036 under two scenarios; one being changes as a result of current conditions and predicted future changes in the absence of the proposed local Plans, the other being those changes anticipated with the proposed Local Plan. Nitrogen deposition maps include separate maps showing depositions for woodlands, as well as shorter habitats such as dwarf shrub heathland/grassland where lower deposition velocities apply.

3.27 **Maps 3.1-3.4** show those areas for different pollutant types in 2015 where the PEC exceeds 100% of the CL, and therefore provide a steer as to where survey (polluted) and control (unpolluted) sample locations could be sited.

3.28 As can be seen from these maps, the most significantly polluted road through the New Forest is the A31, which was the subject of work in 1997 by Angold. This road is also predicted to experience some of the largest increases in pollution into the future, albeit that the Local Plans are not predicted to be making a significant (>1% of CL) contribution to this.

3.29 Examination of broad habitat mapping (see **Maps 3.5** and **3.6**) for **Area 1** along the A31 showed extensive areas of dry heathland, and some areas of wet heathland. In view of this, it was considered likely that a variety of Annex 1 habitats at least including dry and wet heaths, but potentially other more localised Annex 1 habitats, were likely to be found in this location. Wet and dry heathlands benefit from a larger body of information pertaining to the typical effects of air pollution, and the area also benefits from past study by Angold in 1997 and information collected by Sanderson (2003).

3.30 **Area 1** was therefore selected as the main survey area, as the high levels of pollution and existing data mean that it offers the greatest prospect of identifying effects caused by air pollution. This is discussed further below in relation to additional steps that were taken to attempt to control for management factors and other non-air quality-related variables that were overlooked by Angold in 1997.

3.31 In terms of potential control locations:

- **Area 2** was eventually selected to function as a qualitative control location* – this is because the heathlands here are located on top of broadly the same geology as Area

1 (Becton / Chama Sands), and are subject to a fairly low level of pollution – see **Maps 3.1-3.4** (NB: the mapped levels of NOx and nitrogen deposition in this area are likely to be an overestimate, as the 5km grid square in which it falls includes part of Lyndhurst – meaning that the assumed average background pollution in this square is likely to be biased by inclusion of data from Lyndhurst);

- **Areas 3-6** were all considered for their potential to act as a control location due to the fact that they contain ostensibly suitable habitat types, but were rejected:
  - **Area 3** was rejected as 2015 modelling shows that it may already be in exceedance for Ammonia, and aerial imagery showed that large lengths of the adjacent heathland habitat were protected by shelterbelts of trees that may affect the results;
  - **Area 4** was considered due to the availability of existing information for the heathlands in this location, but was rejected due to its high modelled levels of pollutants in 2015;
  - **Areas 5 and 6** were rejected because they are located on a fundamentally different geology to the main survey site (they are located on Headon Beds rather than Becton / Chama Sands), and there is consequently no way to tell whether any difference in vegetation composition or plant health between these locations and the main study site may be due to this factor.

*Qualitative because insufficient time was available for this commission to collect enough transect and quadrat samples for robust quantitative statistical analysis.

Spatial Sampling Strategy

3.32 The Highways Agency (now Highways England) Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 1, provides guidance on assessing air quality impacts for road projects, and states that:

> *"only properties and Designated Sites within 200m of roads affected by the project need be considered"*.

3.33 Whilst the DMRB sets a 200m zone for assessing air pollution impacts from a road, the rate of decline with distance from the roadside within that zone is steeply curved, rather than linear, as indicated in **Figure 3.1** below, and effects are most pronounced within the first 50m. Within this zone, the area potentially affected by nitrogen deposition is influenced by the presence of barriers reducing the dispersion distance of airborne NOx, including roadside tree-belts.

3.34 This presumption is borne out by the results of aggregated studies on a report on *'NO2 concentrations and distance from roads'*[3], which found that the decline of NO2 concentrations is *"essentially linear on a log-linear scale between 10cm from the kerb and 140m from the kerb"*, supporting the view that:

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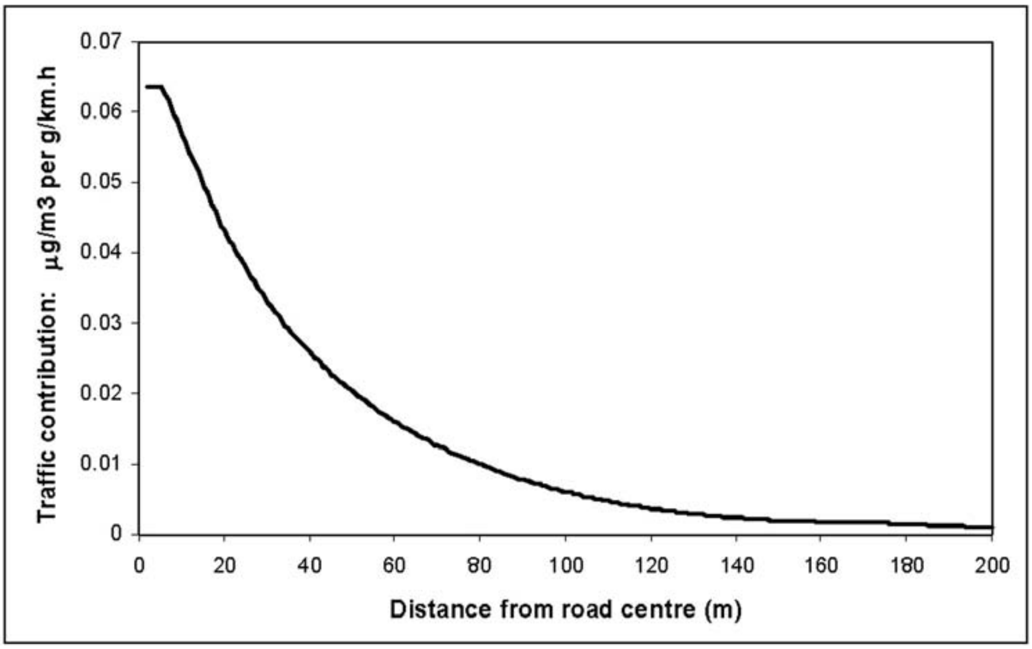
[3] Laxen and Marner. 2008. *NO_2 concentrations and distance from roads*. Report reference - 504/1/F1. Bristol, Air Quality Consultants Ltd.

"beyond 50m from the road, concentrations approach background levels. Thus, at 100m or more from the road, the difference between the total concentration and the background concentration should be as close to zero as will make virtually no difference."

Figure 3.1: Extract from the Design Manual for Roads and Bridges, Volume 11 Section 3 Part 1 'Air Quality' HA 207/07, Figure C1 Traffic Contribution to Pollutant Concentration at Different Distances from the Road Centre.



3.35 In view of the above information, it follows that one can expect a gradient of traffic-related air pollution to exist from the road edge that declines as one moves away from the road, up to a maximum extent of around 200m away.

3.36 Therefore if any observable effects on vegetation composition or plant health in this zone is being affected by traffic related air pollution, as opposed to other factors (discussed above), one would expect any such changes to correlate to the above gradient.

3.37 Additionally, if any trend that can be correlated with this gradient is observed, that information can in theory be used to inform predictions about the way in which similar habitats across the New Forest will change in response to increased air pollution, as habitats will move further up the theoretical gradient as pollution levels increase.

3.38 This has therefore been used to inform the transect sampling strategy described below.

Approach to Investigating Annex 1 Habitats

Overview

3.39 The approach to investigating each Annex 1 habitat type is summarised in **Appendix 1**.

'Short' Habitats

3.40 Of the Annex 1 Habitats, the dry and wet heaths were proposed to be sampled by transect, as these are the only habitat types likely to be sufficiently extensive adjacent to the A31 to make transects possible, and by extension yield the best possible chance of detecting a pollution signal manifested as changes in vegetation composition as the survey moves from the most grossly polluted areas near the road edge toward the extremities of the 200m study area.

3.41 In reality, areas of wet heathland encountered during the survey work were limited areas located on steep valley sides that only supported a narrow wet heath zone. They were also undergrazed, which meant that survey of these specific areas was difficult. Transect work on wet heaths was not therefore possible.

3.42 Smaller, more localised habitats, and those that occur as discrete areas (e.g. within a heathland mosaic or at the ecotones between areas of wet and dry heath or bog, such as the seasonal pools, transition mires, *Rhynchosporion*, fens etc.) were proposed to be recorded only where found in the study areas and in the control areas (due to the fact that vegetation mapping did not allow for their spatial distribution to be accurately predicted prior to field survey).

3.43 Instead, a basic consideration of the risk to other less extensive Annex 1 habitats was carried out by reviewing BSBI records for the locations of the key species.

'Tall' Habitats (Woodlands)

3.44 As informed by literature review, the only likely visible and accurate indicator of air pollution in woodland habitats would be the presence or absence of epiphytic lichen species with known tolerance or aversion to air pollutants.

3.45 Surveying for lichens in a comprehensive manner would have taken more time than was available for this commission, but just as importantly it would not have been possible to match the extensive existing records of lichen species collected by specialists across the New Forest.

3.46 Woodland habitats were therefore assessed with the assistance of a local expert (N. Sanderson), using his access to records of lichen species and many years of experience assessing New Forest habitats. This assessment is included as **Appendix 3**.

Survey Strategy: European Dry Heaths (4030)

The Research Questions

3.47 The questions that have been posed in this study for European Dry Heaths 4030 were:

- is there a significant observable difference between vegetation within and vegetation beyond a polluted 200m road corridor? and
- is there any observable pattern between vegetation within areas affected by the road corridor and changing air pollution concentrations/depositions with distance from the road edge?

3.48 The approach was to carry out stratified randomised transect sampling of the dry heaths vegetation in a 200m corridor either side of the A31. Where particularly sensitive areas of Annex

1 habitat were encountered just beyond the core 200m transect zone (up to around 300m), additional information was noted.

Sample Areas on the A31

3.49 The New Forest has complex vegetation types, including their transitions and mosaics, varying management, landscape history, geology, soils and hydrology. These are formidable variables within which to identify changes in vegetation patterns associated with changes in air quality.

3.50 To try and control for some of these variables, the approach was developed further as outlined below.

Geology: Bedrock and Superficial Deposits

3.51 The A31 passes for much of its distance across a plateau area, albeit dissected by two main drainage systems. The plateau bedrock is relatively uniform - Barton Sands and Chama Sands – (though these two formations are complicated and under revision by the BGS) and both are overlain by River Gravel Terraces.

Topography

3.52 The topography of this plateau is readily seen on the New Forest LiDAR resource and this was used to refine the locations and extent of areas for sampling along the A31 (within Area 1 as seen on **Map 3.6)**.

3.53 All areas that appear to be part of a level plateau as can be seen on the LiDAR were considered for inclusion within the sampling strategy with the following exceptions:

- **Stoney Cross Plain** (where it intersects with the A31) was not sampled as this area is adjacent to farmland (to the north east) that may complicate interpreting changes in air quality and their source; and
- **Valley sides and bottoms** were not included within the sampling for the dry heaths habitat.

3.54 The NFNPA LiDAR map shows the areas of the plateau adjacent to the A31 where the transect samples were placed.

Width of Corridor for Sampling

3.55 The width of the corridor for sampling for this study was set at 200m. As explained previously, this width is based on the DMRB which is, in turn, supported by more recent work (including a paper by Laxen & Marner (2008) and Smithers *et al.* (2016), both of which indicate (directly or by references within) that air quality changes from roads fall to background levels within 200m.

Variable Features on the Plateau within the Corridor

3.56 Within this 200m corridor the heathland plateau that has been sampled by EPR has some variation in geology, hydrology and soils – despite this, it remains a relatively uniform physical feature, and more so in comparison to much of the rest of the New Forest.

Variables Close to the Road Edge

3.57 Within the 200m zone, there are some effects from the edge of the road that will have potential impact on patterns of vegetation that are (largely) independent of air quality. The changes that have been considered and given a subjective assessment of their potential significance are:

- Road edge effects: impacts on adjacent habitats from road construction, drainage;
- Impacts from road structures such as embankments and cuttings;
- Ungrazed road verges extending from carriage way edge to fenceline;
- The type of road (modern vs old);
- Historic land use adjacent to roads (for example gravels pits, old trackways);
- Maintenance/Safety Management adjacent to the road fences; and
- Grazing patterns and intensity adjacent to roads.

3.58 Some, many or all of the above were predicted to be present at any given location on the A31. Their effects have never been formally studied, though they are likely to exert a significant influence on vegetation within the first tens of metres from the edge of the carriageway.

Distribution of Annex 1 Dry Heaths Habitat in the 200m corridor

Relationship Between Annex 1 Habitat and heathland NVC types

3.59 For the purposes of this study, we have considered that the Annex 1 SAC habitat is composed of the following NVC heath types (main sub-communities only):

- H2a *Calluna vulgaris – Ulex minor* Heath, typical sub-community;
- H2c *Calluna vulgaris – Ulex minor* Heath, *Molinia* sub-community;
- H3a *Ulex minor – Agrostis curtisii* Heath, typical sub-community; and
- H3c *Ulex minor – Agrostis curtisii* Heath, *Agrostis curtisii* sub-community.

3.60 The NVC types listed above group into the following two categories:

- Dry Heath = H2a & H3c; and
- Humid Heath = H2c & H3a.

3.61 Lowland heathlands are typically a mosaic of habitats/vegetation types and dwarf shrub vegetation (such as those listed above) can be intermingled with grasslands and wetlands to form a natural range of vegetation; this was taken into account when recording and describing.

3.62 A description of the New Forest dry heath habitats (taken from the New Forest SAC Management Plan (2001)) is provided below:

> *“The New Forest dry heaths comprise a suite of vegetation communities defined largely along a soil moisture gradient. The various communities are identifiable as nodes along a continuum from the driest, poorest soils through those of intermediate moisture and slightly higher nutrient status to those too wet to support Erica cinerea but not wet enough to support Sphagna and wet heath communities. This classification embraces the traditional*

classification of Forest dry and humid heath e.g. Tubbs (1986) an Westerhoff & Clarke (1988), but provides greater definition and enables comparative evaluation against other heathland communities at the national and European level to be made. (In particular it avoids the difficulties and potential confusion of the inclusion of E. cinerea in the definition of humid heath in the Westerhoff & Clarke definition).

In terms of the NVC the driest heaths are referable to H2a and H3c, whilst increasing soil moisture brings in H2c, H3a and H3b and an additional community not described in the NVC. The latter, an extreme form of H2c, occurs on soils too wet for E. cinerea but not wet enough for Sphagna, and which Sanderson (1992) has provisionally named Calluna-Molinia-Erica tetralix-Leucobryum glaucum heath. This community is the true 'humid heath' in the more widely accepted sense of the term, which in the New Forest is an extensive band between the drier communities and wet heath.

All are included within the Habitats Directive Annex 1 habitat: European Dry heaths.

Whilst soil moisture and probably soil nutrient status are the principle community determinants, the physical structure / appearance of the dwarf-shrubs and presence and abundance of associated species are heavily influenced by burning and grazing.

There are around 7,600 ha of dry heath in the New Forest.

When in favourable condition dry heath exhibits a structural mosaic of ericaceous vegetation with at least 10% young (pioneer phase for Calluna vulgaris) and between 20% and 50% old (mature or degenerate phase for C. vulgaris). Cover of C. vulgaris lies between 25% and 90%. There is between 1% and 10% bare ground forming an intimate mosaic with the vegetation, but not in an extensive form as a result of intensive stock feeding or human disturbance. Cover of invasive species… would require management intervention."

Dry Heath Sampling Strategy: Number and Locations of Transects

3.63 To enable future statistical analysis as appropriate, the number of transects was increased to c. 30 to provide a robust sample size. The transects were placed in the Annex 1 dry heaths habitat, aiming to record 15 transects from each side of the A31.

3.64 Transects were located on both sides of the road meeting locational criteria (to enable the variables described above to be accounted for and controlled if necessary), as opposed to always having paired transects on either side of the road.

Dry Heath Sampling Strategy: Quadrat Locations and Areas

3.65 For each transect, the approach taken was to record five or six quadrats at the following distances from the road edge:

- 25m;
- 50m;
- 75m;
- 100m;

- 150m (inclusion subject to review during data collection); and
- 200m (this sample is, in effect, beyond changes in Air Quality associated with the road according to the best available evidence).

3.66 No quadrats were recorded from the 0-25m zone from the edge of the road as this is where most of the observable effects of road edges other than air pollution (as listed above) are seen. A qualitative comment on this zone has however been made for each transect line.

3.67 The size of the quadrat recorded at each of the sampling points on a transect was 1m x 1m to enable a larger number of samples to be recorded in the time allocated. The revised strategy gave between 150 and 180 quadrats from 30 sample points at 5 or 6 specific distances from the road edge.

3.68 Information recorded in each quadrat included:

- Grid reference: Garmin 62s (accuracy to be noted as displayed on the Garmin Unit but it is likely to be in the region of c. 10m precision);
- Altitude (from GPS);
- Slope and aspect;
- Plant species and relative abundance using Domin;
- Bryophyte species and relative abundance using Domin;
- Lichen species and relative abundance using Domin;
- Management (grazed/not grazed; burned (date of last burn from FC);
- *Calluna* height and approximate stage in heather cycle; and
- Description of any obvious signs of damage to *Calluna* (with photographs).

3.69 The output for each quadrat following the analysis of these data was:

- NVC (or other description) of the vegetation type;
- Whether the vegetation is Annex 1 Habitat;
- Ellenberg Values for all Vascular plants per quadrat;
- Ellenberg Values for Bryophytes;
- Species Composition; and
- Summary of Condition of Vegetation.

Survey Strategy: Wet Heaths (4010)

3.70 As mentioned above, it was not possible to carry out transect surveys in areas of wet heaths within Area 1, due to the limited extent of this habitat type and its location on steep-sided undergrazed valleys, making meaningful data collection difficult.

3.71 The extent of the dry heaths adjacent to the roads in the New Forest made that habitat one suitable for the sampling strategy, as a sufficiently large number of data samples could be collected to make meaningful quantitative analysis possible, and act as a model for investigating potential changes associated with changes in air quality whilst controlling for other variables.

3.72 Wet heaths are a much less extensive habitat closer to roads; the routes of most roads will attempt to avoid extensive areas of wet ground and this is the case with the A31, where wet heath habitat is very limited in the 200m corridor in contrast to the dry heaths.

3.73 Two locations associated with the A31 were visited, one of which is parallel to the road and the other perpendicular. The first location is at SU204071 and the second at SU221087. These are marked as 'Wet Heath Locations 1 and 2' on **Map 3.5 and 3.6**.

3.74 For the valley parallel to the road, it was intended to carry out a transect in the wet heath parallel to the road to see what variation was present. For the valley perpendicular to the road, the transect was intended to be perpendicular, to look at variation across a gradient of pollutant loads/levels.

3.75 A description of the New Forest wet heaths (taken from the New Forest Management Plan (2001) is provided below:

> *"The New Forest wet heaths comprise a suite of vegetation communities defined by soil moisture, nutrient and base status, and profoundly influenced by burning and grazing. Soil are too dry to sustain the large peat-building Sphagna associated with mires but too wet to support Erica cinerea. There is no real dominance of Calluna vulgaris as generally occurs in the later successional stages following burning on dry heaths.*
>
> *In terms of the NVC there are three main sub-communities, of M16 Wet Heath: M16a, M16b and M16c. There is also a more base-rich and extreme form of M16b occurring locally on marl in the New Forest. These embrace the 'wet heath' of the Westerhoff & Clarke vegetation survey (1998) and the 'wet heath' (which corresponds to M16a, M16c) and 'tussock heath' (which corresponds to M16b) of Tubbs (1986).*
>
> *Two Annex 1 habitats are present:*
>
> 1. *Northern Atlantic wet heaths with Erica tetralix – incorporates M16a and M16b.*
> 2. *Depressions on peat substrates (Rhynchosporion) – incorporates M16c."*

Interpretation: Wet and Dry Heaths

3.76 Qualitative and (where both possible and appropriate) quantitative analysis of the information that was collected aimed to:

- Investigate the relationship between vegetation types and distance from road;
- Investigate the relationship between vegetation types/species composition/distance from road;
- Investigate the relationship between Ellenberg values and distance from road; and
- Compare sample sites along the A31 with the control samples taken along the B3056.

Control Data: Wet and Dry Heaths

3.77 Control Data covered two aspects:

a) Vegetation types/species composition at the edge of the 200m road corridor zone – this was in the area of background deposition and beyond the (detectable) range of air quality associated with the A31; and

b) Qualitative comparison of road edge effects between the circumstances of the A31 and a rural road, the B3056 (**Area 2** shown on **Map 3.5**) – this was to help interpret what road effects are present in the Forest irrespective of air quality changes associated with roads.

4. RESULTS: ANALYSIS & INTERPRETATION

Introduction

4.1 The results in this section cover three distinct areas of investigative work:

- Field work to examine Annex 1 Habitat 4030 European Dry Heaths;
- A review of evidence pertaining to potential effects that may be occurring to the Annex 1 woodland habitats of the New Forest SAC and their internationally important epiphytic lichen assemblage, carried out by Neil Sanderson, an expert on New Forest woodlands and their lichens; and
- A review of botanical data on a number of species characteristic of Annex 1 Habitats other than the Annex 1 Habitat 4030 European Dry Heaths and the Annexed woodland habitats.

4.2 An overview of the results obtained and their analysis and interpretation is provided below.

Field work to examine Annex 1 Habitat 4030 European Dry Heaths

Results: A31 Transects

4.3 30 transects (of 5 quadrats each) perpendicular to the A31 were surveyed by Andrew Cross in May 2018. 15 transects were carried out south of the A31, and 15 to the north. **Map 4.1** shows the location of the transects.

4.4 The vegetation recorded in the 150 quadrat samples was referable to the following NVC types:

- Humid Heath H3a *Ulex minor – Agrostis curtisii* Heath, typical sub-community;
- Dry Heath H3c *Ulex minor – Agrostis curtisii* heath, *Agrostis curtisii* sub-community;
- Parched Acid Grassland U1 *Festuca ovina Agostis capillaris Rumex acetosella* grassland; and
- Heathy Acid Grassland U3 *Agrostis curtisii* grassland.

4.5 A list of the species recorded in the survey area is given in **Appendix 4.**

4.6 One prominent vegetation type present in the survey area but not sampled in quadrats was:

- Gorse-Bramble scrub W23 *Ulex europaeus - Rubus fruticosus* scrub.

4.7 Gorse *Ulex europaeus* occurs throughout the survey area, though most prominently nearer to the A31 than the 200m limit of the survey. The Gorse is an ancient feature of this landscape matching with the Gorse as mapped on the 25/6 inch to the mile OS maps of the 1860s. The Gorse tends to occur with Bramble, and this community is referable to the NVC type W23 *Ulex europaeus - Rubus fruticosus* scrub. This is a community here of disturbed soils.

4.8 The Forestry Commission provided spatial information on the management carried out in the survey areas, which was managed burns, cutting, cut and baling, and Bracken management.

The Forestry Commission also provided information on wildfires. **Maps 4.2 to 4.6** show the distribution of management types and the year of management.

Research Questions Driving Analysis

4.9 The primary research questions that the fieldwork methodology sought to provide information to address (see **Section 3** above) on European Dry Heaths 4030 were:

1: Is there a significant observable difference between vegetation within and vegetation beyond a polluted 200m road corridor? and

2: Is there any observable pattern (correlation) between vegetation within areas affected by the road corridor and changing air pollution concentrations/depositions with distance from the road edge?

Quantitative Analysis

Overview

4.10 Potential data trends were explored graphically using simple bar charts displaying descriptive statistics for the mean (average) and standard error (which reflects the amount of variance around the mean) for each recorded transect variable with increasing distance from the road.

4.11 Variables were selected for further statistical analysis where the plotted mean and standard error data indicated the potential for correlation of a variable with distance, or the potential for a significant difference in a variable with distance, <u>and</u> where data did not carry large standard error values that would exclude a meaningful result.

4.12 In addition to pre-survey control measures to exclude potentially confounding variables (explained in **Section 3**), some data points were excluded from statistical analysis on the basis that they might reduce the clarity of the analysis and result. Only 7 quadrats (of a total of N=150) were obtained for NVC habitat types U1 (N=2) and U3 (N=5). Given the difference in composition between these habitat types and H3 habitats, within which all other quadrats were sampled, data for U1 and U3 habitats was excluded from the statistical analysis reported on below. Data for the separate control site (**Area 2** shown on **Map 3.6**) was also excluded from statistical analysis owing to the limited sample size of the data that was able to be collected (2 transects, 10 quadrats). Overall, data for 143 quadrats sampled over 30 transects located to the north and south of the A31 corridor were analysed statistically.

4.13 Data was cleaned before analysis to ensure potential data entry errors did not affect the accuracy of results. Most data collected was analysed in its raw format, namely species number per quadrat and percentage cover. However Ellenberg values associated with the species recorded in each quadrat were converted into a weighted score based on percentage cover. This was done to ensure that the total Ellenberg score recorded for each quadrat was representative of both species presence and relative abundance. There are a number of different Ellenberg values associated with any one species which reflect that species' response to different environmental gradients, including light, moisture, acidity, fertility and salinity. Ellenberg values were taken from PLANTATT (Hill et al. 2004) and BRYOATT (Hill et al. 2007), with values for acidity and fertility subject to analysis.

4.14 Simple univariate (single variable) statistics were carried out using Minitab and/or SPSS owing to the time and data constraints of this study. Univariate statistics can look at differences and patterns, but not 'cause and effect' which requires more complex multivariate analysis- the potential to carry out more complex analyses should be considered as part of future monitoring work, as in theory the data that are collected could be made subject to this type of interrogation.

4.15 Two types of statistical analysis are possible: 'parametric' or 'non-parametric'. Parametric statistics are more powerful and are therefore preferred, but require a number of specific assumptions regarding the form of the data being analysed to be met, including that the data conforms to a normal distribution. Non-parametric statistics do not require data to conform to a particular distribution, nor to meet other assumptions, but as a result are less powerful and are only able to answer less complicated questions. If the assumptions for parametric statistics cannot be met, then non-parametric tests are safer because they are less likely to result in either a 'Type I' or 'Type II' error. A Type I error results in rejection of a null hypothesis that is actually true, i.e. a 'false positive'. A Type II error accepts a null hypothesis that is actually false, i.e. there is a difference that has not been detected; small sample sizes often lead to a Type II error (Dytham, 2002).

4.16 Data was therefore subject to Anderson-Darling testing to check for normality of data distribution. Owing to the categorical nature of the data recorded, all variables displayed a non-normal distribution, ruling out the robust use of parametric statistical testing.

4.17 The following tests were therefore used:

- Non-parametric Kruskal-Wallis Test to test for significant differences in variables between distance categories (Research Question 1);
- Non-parametric Mann-Whitney U Test to test for significant differences in variables between two specific distance categories (in essence post-hoc testing, which is not available for the non-parametric Kruskal-Wallis Test; Research Question 1); and
- Non-parametric Spearman's Rank-order Correlation to test for correlation of a variable with distance from the road (Research Question 2).

4.18 One-Way Analysis of Variance (ANOVA) was also used to test for significant differences in variables between distance categories. Although One-Way ANOVA is a parametric test, the use of which is not supported by the distribution of the datasets being analysed, quick and easy post-hoc testing using the Fishers Test of Least Significant Difference (LSD) is possible to discern the data group(s) that have the potential to differ significantly, which was used to guide the application of the aforementioned univariate (non-parametric tests.

Results

4.19 **Figures 4.1** to **4.14** display the mean and standard error for a number of variables with increasing distance from the road (graphs for all variables recorded are provided at **Appendix 5**).

4.20 Notable differences in certain types of habitat management were observed across distance categories, with the mean number of years since last burn and last bail increasing at 200m from the A31. The mean number of years since last wildfire was higher closer to the road at a distance of 25m, although the variance (standard error) around the mean number of years for distances

50, 75, 100 and 200m was such that any correlation in years since wildfire with distance was unlikely to be significant. Other notable differences in variables recorded across distance categories were also observed, including:

- Higher mean *Calluna vulgaris* height at 200m from the road;
- Decreasing mean percentage cover of *Agrostis curtisii* with increasing distance from the road;
- Increasing mean percentage cover of *Erica tetralix* with increasing distance from the road;
- Mean percentage cover of *Hypnum jutlandicum* initially decreased, then increased with increasing distance from the road (although the data had large overlapping standard error values);
- Increasing mean percentage cover of *Molinia caerulea* with increasing distance from the road;
- Higher mean percentage cover of *Ulex europaeus* seedlings at 25m from the road; and
- Decreasing mean species richness (species number) with increasing distance from the road.

4.21 No pattern was apparent for the remainder of the variables considered, nor in relation to the weighted Ellenberg scores calculated for fertility and acidity (graphs of mean and standard error are provided at **Appendix 5**). For many species, the frequency and relative abundance with which they were recorded within quadrats varied as much within distance categories as between distance categories, as indicated by the large standard error values calculated around the mean.

4.22 Spearman's Rank-order Correlation analysis was carried out for the variables where a potential correlation was observed following graphical analysis. Analysis was also carried out for key variables where no pattern was apparent, for the avoidance of doubt. **Table 4.1** presents the results of this analysis, where P-values less than 0.05 indicate a significant correlation. Significant correlations are indicated in the table below by an emboldened asterisk * after the P-value.

4.23 Most of the analysis involved testing for a significant correlation of an individual variable with distance, however further testing was carried out to explore potential relationships between key species, or between species and the frequency of managed burns. It is noteworthy that data regarding age since last burn was incomplete, with data from the Forestry Commission only available for 58 of the 143 quadrats; this reduced sample size may have affected the outcome of statistical testing.

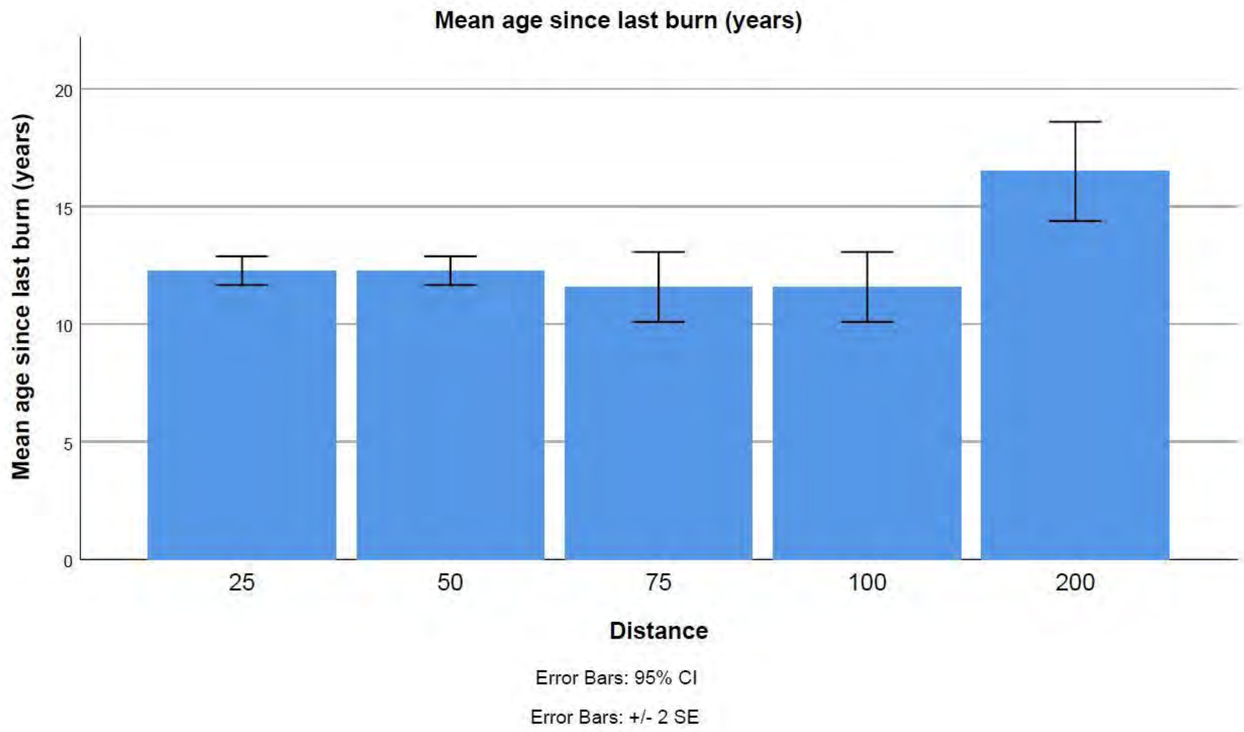


Figure 4.1: Mean age since last burn (years) against distance (m) with standard error bars.

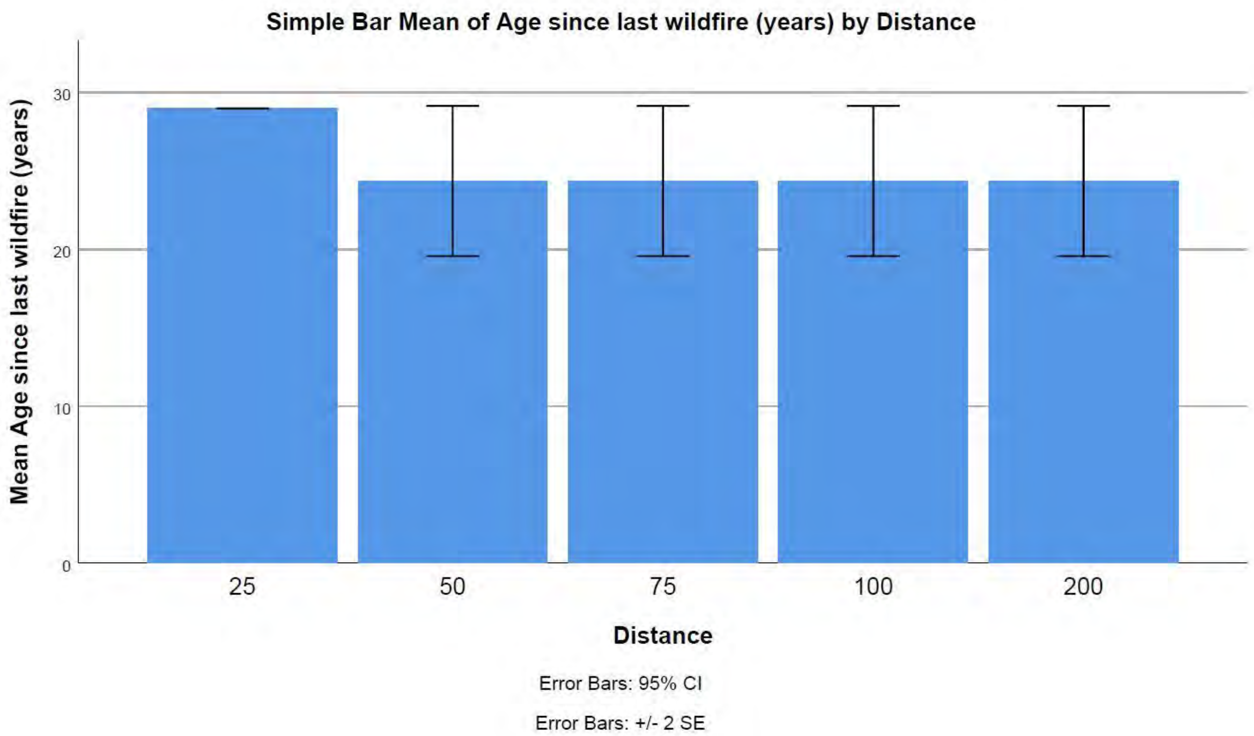


Figure 4.2: Mean age since last wildfire (years) against distance (m) with standard error bars.

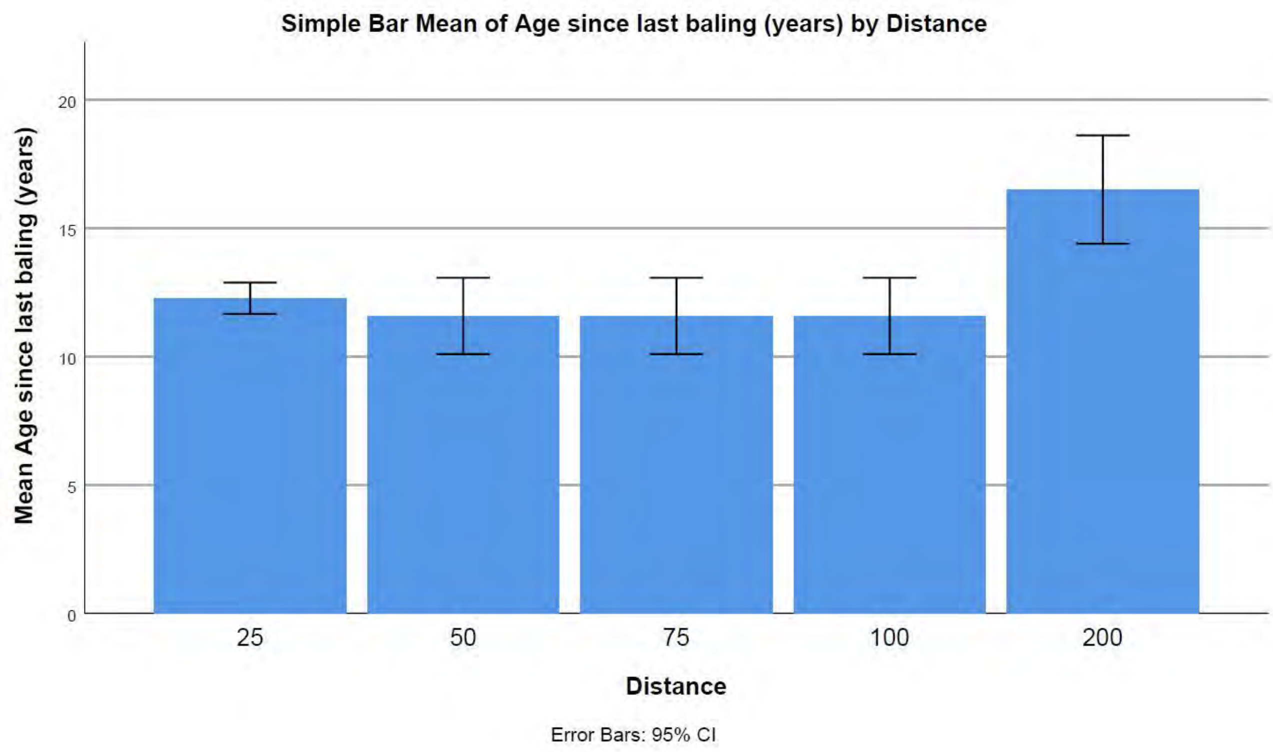


Figure 4.3: Mean age since last bailing (years) against distance (m) with standard error bars.

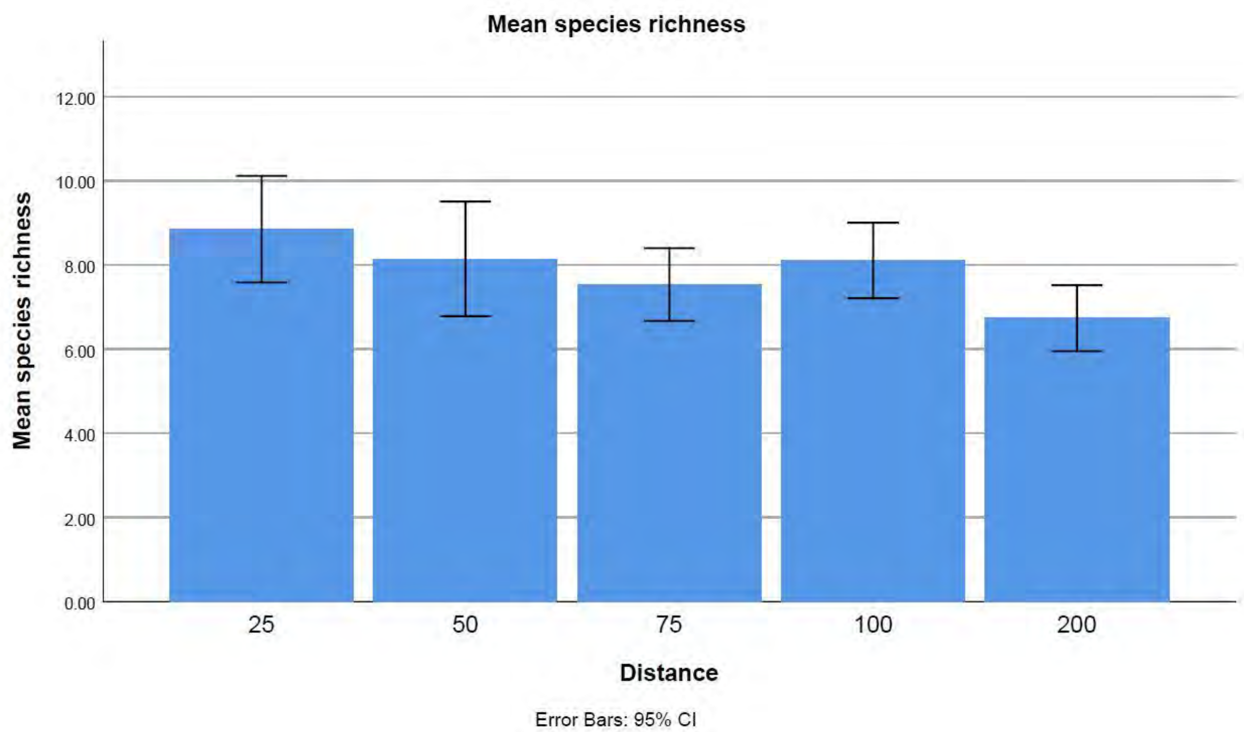


Figure 4.4: Mean species richness (species number) against distance (m) with standard error bars.

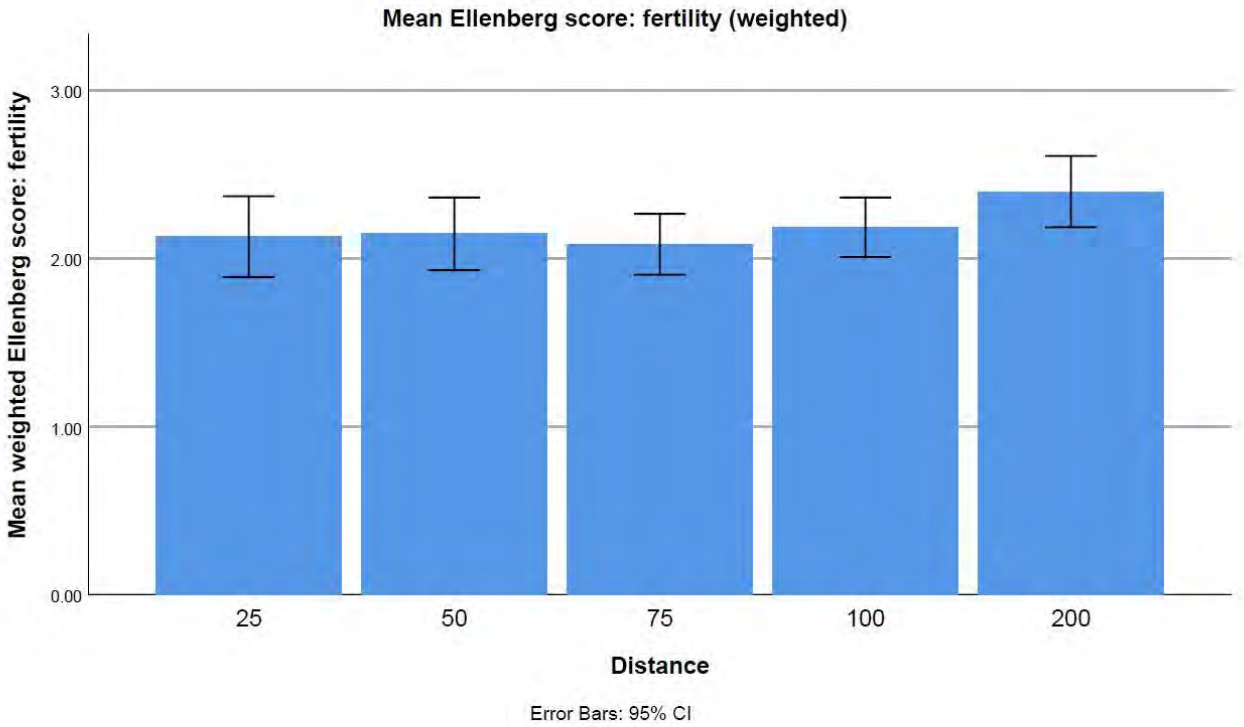


Figure 4.5: Mean weighted Ellenberg score per quadrat for fertility against distance (m) with standard error bars.

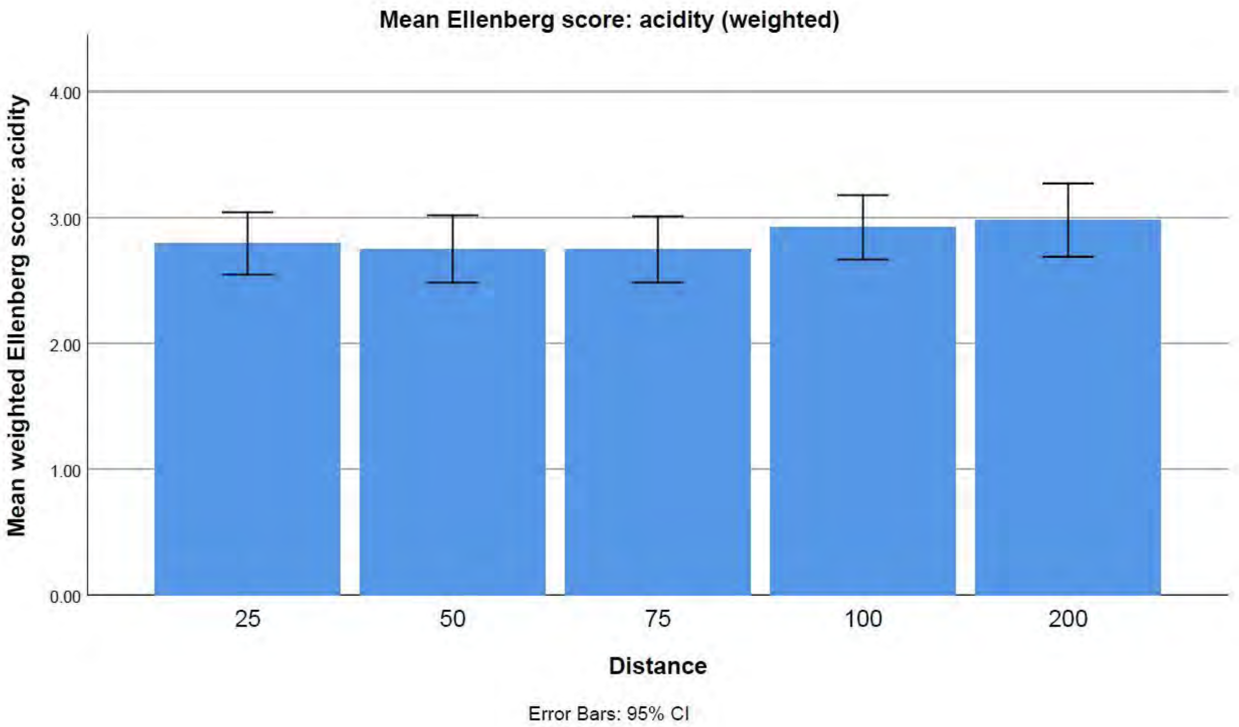


Figure 4.6: Mean weighted Ellenberg score per quadrat for acidity against distance (m) with standard error bars.

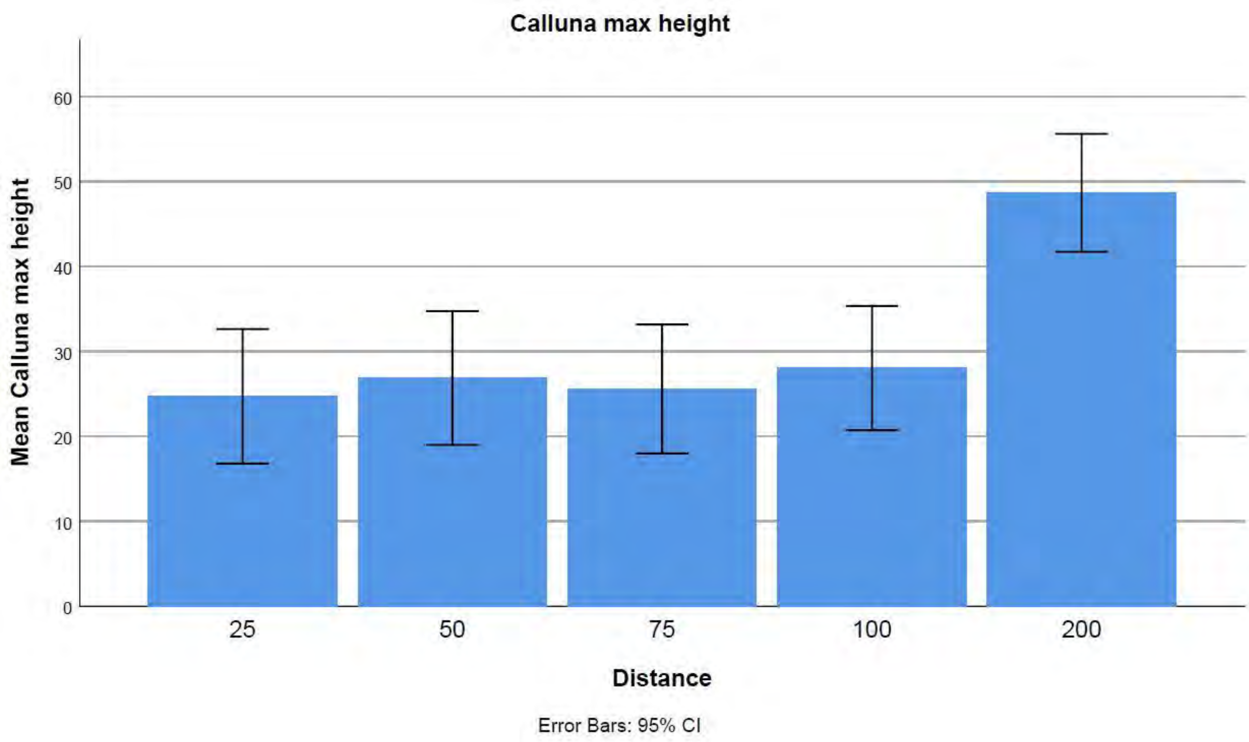


Figure 4.7: Mean height of *Calluna vulgaris* (cm) against distance (m) with standard error bars.

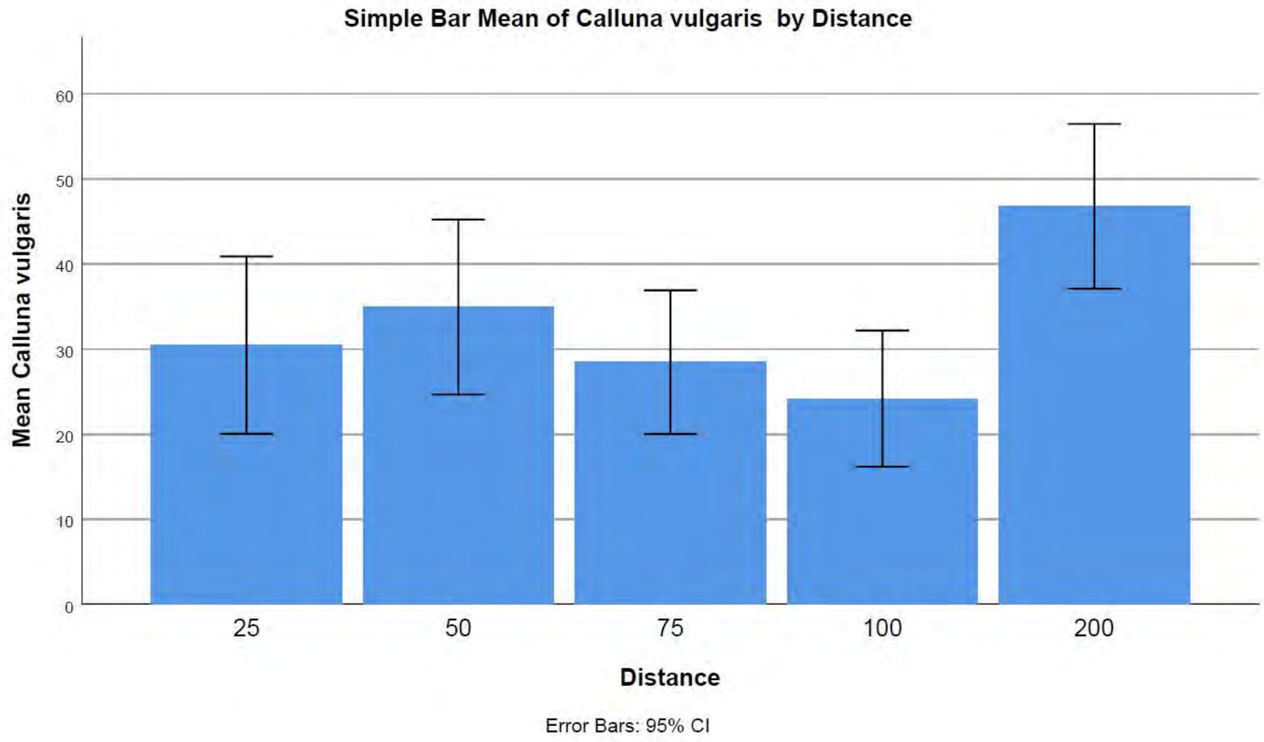


Figure 4.8: Mean percentage cover of *Calluna vulgaris* against distance (m) with standard error bars.

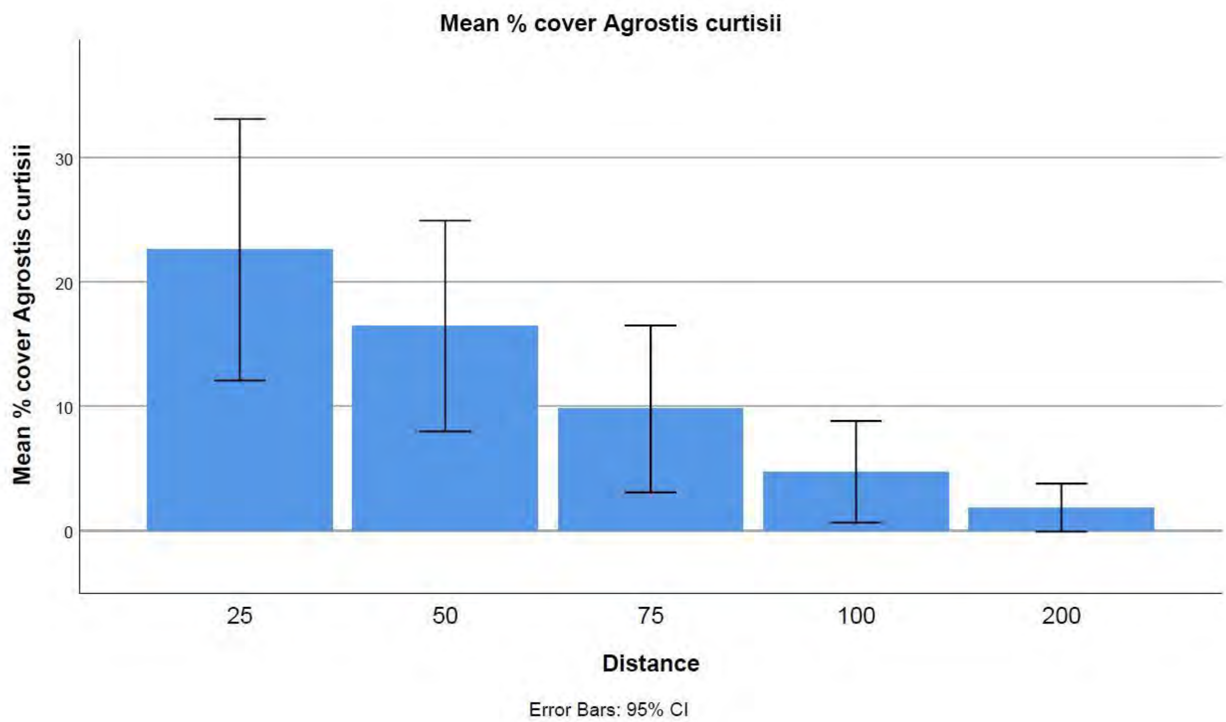


Figure 4.9: Mean percentage cover of *Agrostis curtisii* against distance (m) with standard error bars.

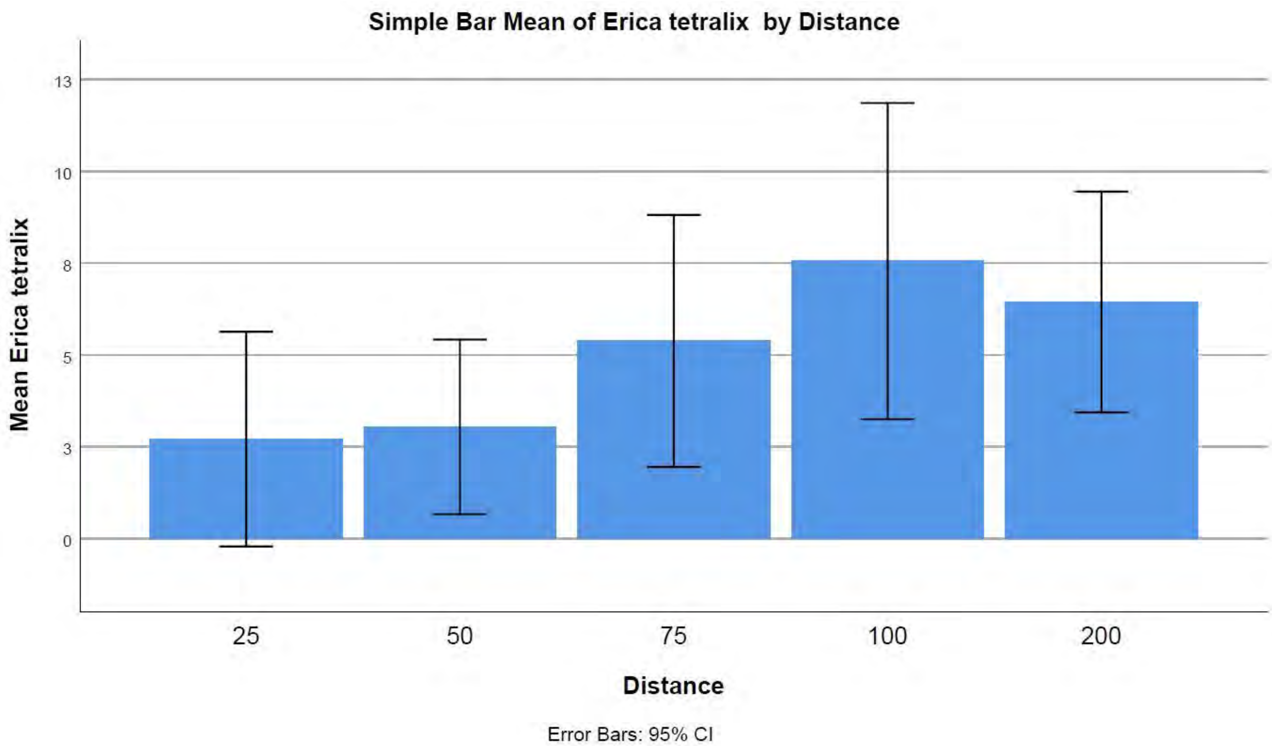


Figure 4.10: Mean percentage cover of *Erica tetralix* against distance (m) with standard error bars.

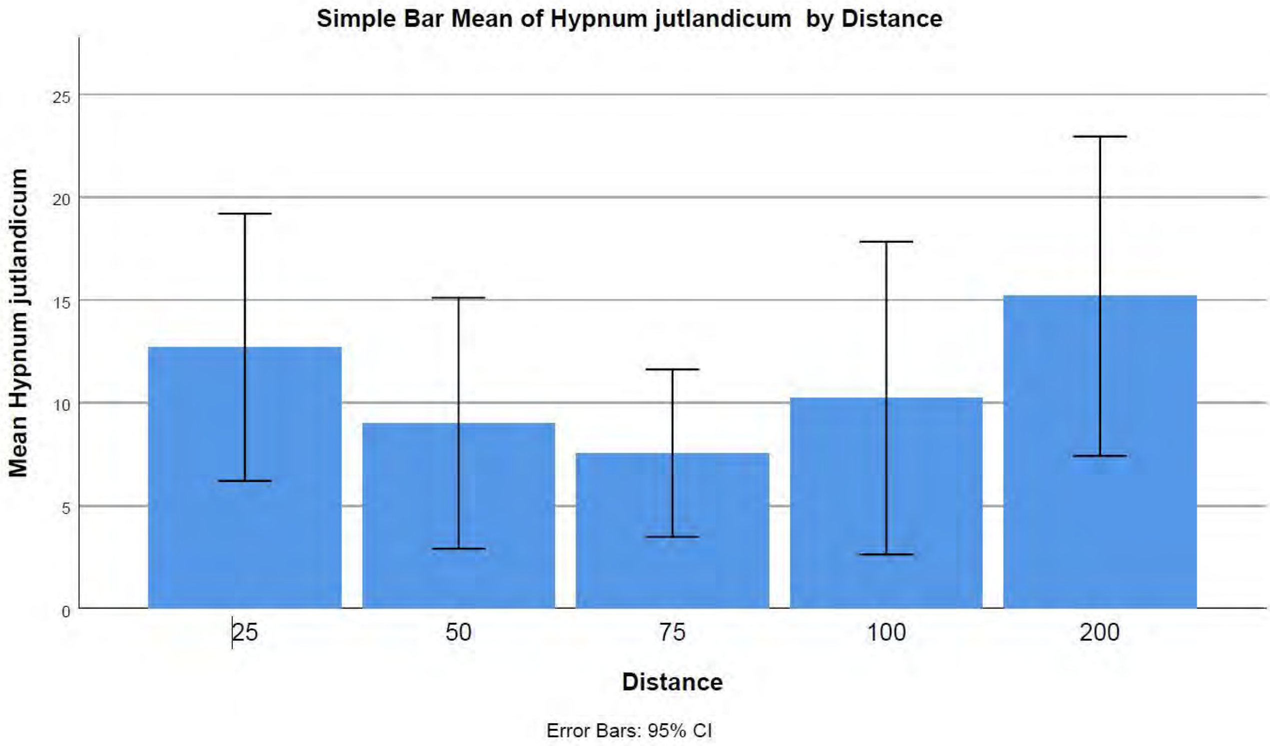


Figure 4.11: Mean percentage cover of *Hypnum jutlandicum* against distance (m) with standard error bars.

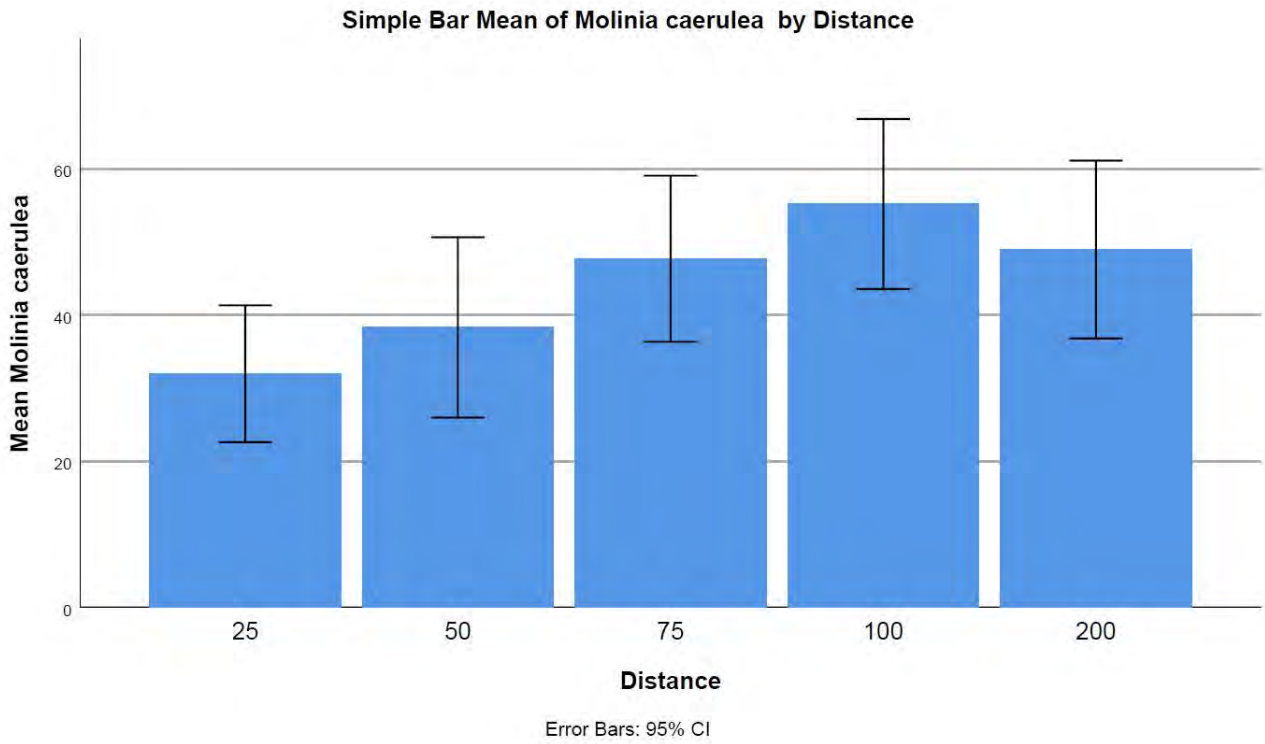


Figure 4.12: Mean percentage cover of *Molinia caerulea* against distance (m) with standard error bars.

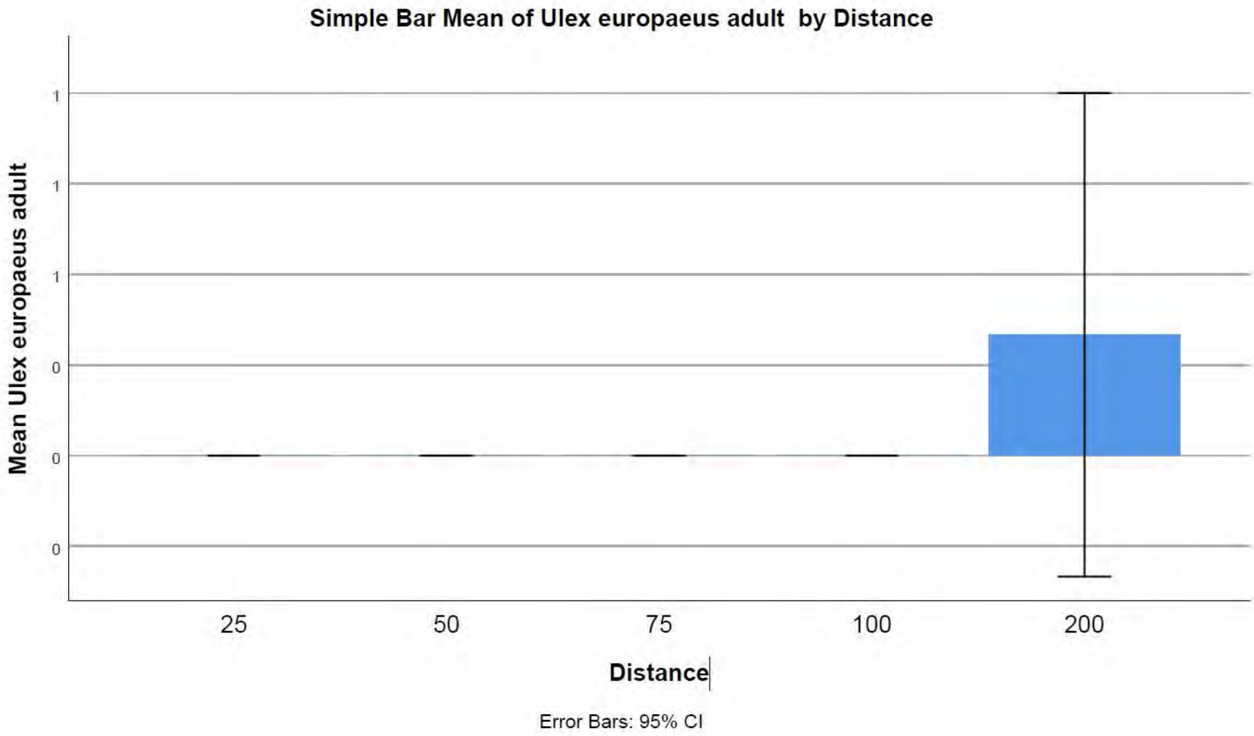


Figure 4.13: Mean percentage cover of *Ulex europaeus* (adult) against distance (m) with standard error bars.

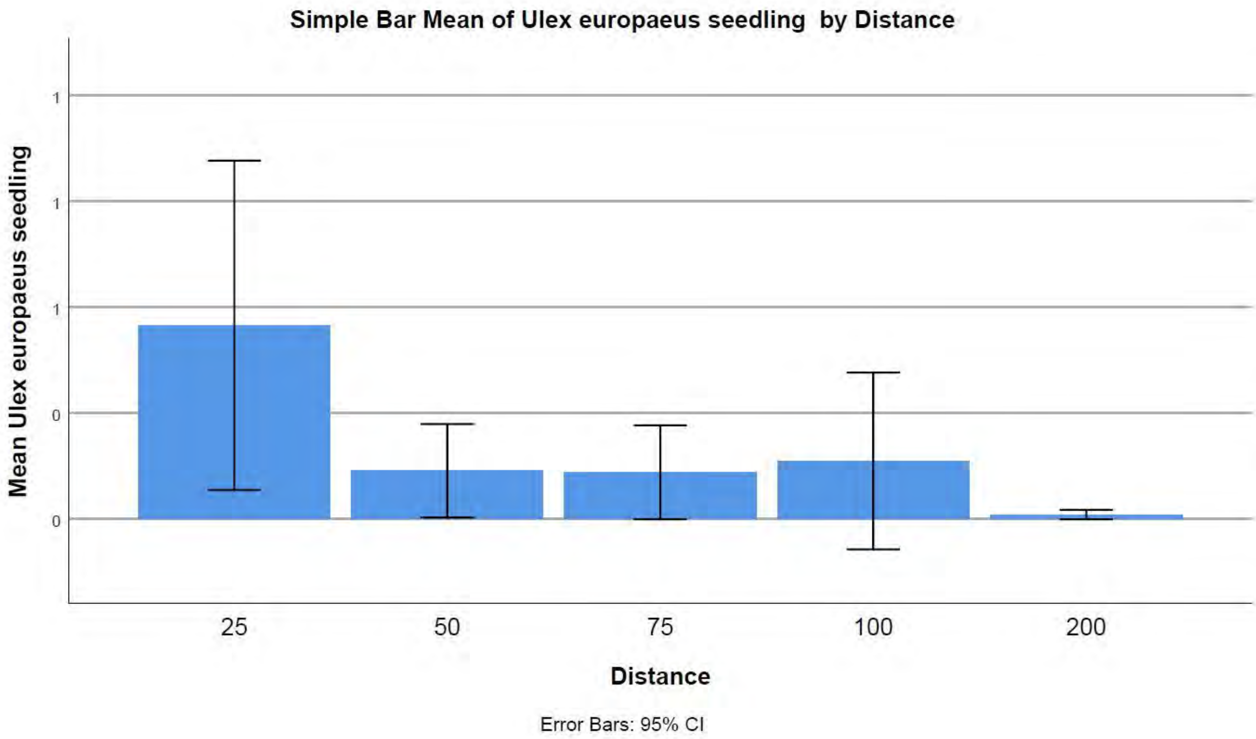


Figure 4.14: Mean percentage cover of *Ulex europaeus* (seedling) against distance (m) with standard error bars.

Table 4.1: Results of Spearman's Rank-order Correlation analysis.

Variables Tested	P-values (Significant differences are indicated by *)
Distance and age since last burn	0.006*****
Distance and age since last wildfire	0.517
Distance and age since baling	0.006*****
Distance and species richness	0.015*****
Distance and weighted Ellenberg score for Fertility	0.178
Distance and weighted Ellenberg score for Acidity	0.220
Distance and *Calluna vulgaris* height	0.000*****
Distance and *Calluna vulgaris* cover	0.272
Distance and *Agrostis curtisii* cover	0.000*****
Distance and *Erica tetralix* cover	0.000*****
Distance and *Hypnum jutlandicum* cover	0.748
Distance and *Molinia caerulea* cover	0.024*****
Distance and *Ulex europaeus* cover (adult)	0.163
Distance and *Ulex europaeus* cover (seedling)	0.000*****
Age since burn and *Calluna vulgaris* height	0.01*****
Age since burn and *Calluna vulgaris* cover	0.564
Age since burn and *Agrostis curtisii* cover	0.152
Age since burn and *Molinia caerulea* cover	0.168
Calluna vulgaris cover and *Agrostis curtisii* cover	0.000*****
Calluna vulgaris cover and *Molinia caerulea* cover	0.000*****

4.24 Where a significant correlation was observed between one variable and another, tests for significant differences were also carried out to discern whether differences could be observed at specific distances from the road. The results are presented in **Table 4.2**.

Table 4.2: Results of tests for significant difference in variables with distance.

	Parametric testing		Non-parametric testing	
	One-Way ANOVA	Fishers LSD Post-hoc Test	Kruskall-Wallis	Mann-Whitney U Post-hoc Test
Variables Tested	P-values (Significant differences are indicated by *)			
Age since last burn with distance	0.000*		0.001*	
Age since last burn- 25, 50, 75 and 100m with 200m		0.000*		
Age since bailing with distance	0.000*		0.001*	
Age since bailing- 25, 50, 75 and 100m with 200m		0.000*		
Species richness with distance	0.063		0.038*	
Species richness with distance- 25 and 200m		0.005*		0.000*
Calluna height with distance	0.000*		0.000*	
Calluna height- 25, 50, 75 and 100m with 200m		0.000*		
Agrostis curtisii cover with distance	0.000*		0.000*	
Agrostis curtisii cover- 25 with 75m		0.01*		
Agrostis curtisii cover- 25 with 100 and 200m		0.000*		
Agrostis curtisii cover- 50 with 100 and 200m		0.02*, 0.003*		
Erica tetralix cover with distance	0.196		0.004*	
Molinia caerulea cover with distance	0.089		0.110	
Ulex europaeus cover (seedling) with distance	0.027*		0.004*	
Ulex europaeus cover (seedling)- 25m with 50, 75, 100 and 200m		0.018*, 0.027*, 0.07*, 0.03*		

Summary

4.25 With regards to Question 2, significant correlations were observed between the following species variables and distance from the A31; species richness, *Calluna vulgaris* height, *Agrostis curtisii* cover, *Erica tetralix* cover, *Mollinia caerulea* cover and *Ulex europaeus* seedling cover. Significant correlations were also observed between age since last burn and bailing and distance from the road, and between *Calluna vulgaris* height and age since last burn. Although *Calluna vulgaris* cover was not correlated with distance from the road, the cover of *Agrostis curtisii* and *Molinia caerulea* was significantly correlated with *Calluna vulgaris* cover.

4.26 With regards to Question 1, habitats were recorded as being burnt significantly more often (with fewer years since last burn) at 25, 50, 75 and 100m as compared to 200m, with the same results obtained in relation to bailing as a habitat management measure and with Calluna height, the latter potentially arising as a result of such habitat management. Species richness was significantly higher at 25m from the road than at 200m, reflecting the increasing dominance of mature (and taller) Calluna. Significant differences in *Agrostis curtisii* cover were recorded at: 25 and 75m; 25, 100 and 200m; and 50, 100 and 200m. The cover of *Ulex europaeus* seedlings was significantly higher at 25m than at all other distances, reflecting the frequency of disturbance.

4.27 The above results call into question the key factor(s) driving community composition within the 200m road corridor: small-scale changes in nitrogen deposition, or large-scale cycles in habitat management? The absence of significant differences and significant correlations between *Calluna vulgaris* cover, Ellenberg scores and distance from the road, set against significant differences and correlations between burning, bailing, Calluna height, cover of key grass species and species richness suggests that habitat management may be a prominent driver of community composition within the areas studied. More frequent burning and bailing adjacent to the road appears to be opening up the structure of the habitat by reducing Calluna height and shading, allowing colonisation by grasses and other species, with consequent increases in species richness. As the frequency of habitat management decreases, Calluna stands become more mature with the taller vegetation structure reducing species richness.

Qualitative Analysis

Question 1: is there a significant observable difference between vegetation within and vegetation beyond a polluted 200m road corridor?

4.28 Almost all the vegetation in the survey quadrats is referable to the NVC type H3 *Ulex minor – Agrostis curtisii* heath. H3 vegetation was recorded in quadrats at all distances from the road.

4.29 This H3 heath vegetation has a varied appearance owing to a complex pattern of management carried out in the area of the Forest where the survey was carried out and variations in grazing intensity. In some areas the H3 will be low, short vegetation and in others it is up to 70cm tall; they are still both H3 vegetation.

4.30 Some areas of U3 *Agrostis curtisii* occur within the 200m zone with none recorded in the 30 quadrats at the 200m line. H3 heathland and U3 *Agrostis curtisii* dry acid grassland vegetation types are very closely related and can shift between each other according to management (e.g. burning) and grazing intensity.

4.31 With reference to the National Vegetation Classification, there is no observable difference between the vegetation recorded within 200m of the A31 and that recorded at 200m from the road edge.

4.32 The condition of the heathland vegetation within the 200m study area adjacent to the A31 was considered against the Common Standards Monitoring (CSM) Guidance for Lowland Heathland (JNCC, 2004), and in all cases would have resulted in a favourable condition assignment, with the exception of criterion 5.2.5 (Acrocarpous mosses < occasional). This is because the non-native acrocarpous moss *Campylopus introflexus* was widespread (probably frequent) though with low cover. However, this was no different to heathland beyond the 200m zone, and it is notable in particular that the control plots recorded for this study also contained abundant *C. introflexus* with high cover (often 50% of the quadrat area).

Question 2: is there any observable pattern (correlation) between vegetation within areas affected by the road corridor and changing air pollution concentrations/depositions with distance from the road edge?

4.33 In order to answer this question, it is necessary to consider the types of patterns or correlations that would be expected from nutrient/reactive nitrogen from road traffic being deposited on adjacent land.

4.34 Previous research (e.g. Laxen & Marner, 2008) shows that there is a gradient of reactive nitrogen deposition that is highest near the road, dropping rapidly at first and then tapering down to background levels by around the 200m mark.

4.35 This pattern of nitrogen deposition is believed to increase the fertility of the soil. If so, there would, in theory, be a soil fertility gradient highest in a zone both nearest and parallel to the road, which tapers off further away from the road.

4.36 It is considered that higher fertility favours grasses over heathers (grasses being more effective at utilising the reactive nitrogen deposited on the ground). Thus, there are two expected patterns that would emerge, and which should be observable, if nutrient nitrogen from road traffic is indeed affecting vegetation in this way within the study area:

- **Pattern 1 –** A higher fertility zone closest to the road edge would be comprised of grassland, that would change (according to the rate of fall off in nutrient deposition) to heather-dominated vegetation further from the road.

- **Pattern 2** – The second pattern is that associated with the relatively uniform sampling area chosen for this 2018 study, i.e. a plateau on relatively uniform geology. This means that there should be the same grassland to heath gradient along the whole length of the sample area. This also implies that there would be a continuous zone of grassland parallel to the road (in the more nutrient rich zone) for the whole length of the plateau.

Interpretation of EPR's 2018 Survey Work

Pattern 1: Is there a gradient of grassland changing to heath perpendicular to the A31?

4.37 The data collected by our fieldwork does not suggest that there is any evidence for such a continuous gradient occurring within the 200m zone in surveyed areas of dry heath along the A31. The changes noted are much more abrupt and appear better related to differential management or grazing pressure.

4.38 There are locations where there is grassland (U3) - often in a mosaic with Gorse-Bramble (W23) and/or Bristle Bent Heath (H3) – the grass-heath described by Tubbs and Rodwell. These U3 grassland zones are of variable width and then merge with varying degrees of abruptness into predominantly H3 heath. In other locations on the A31, there is H3 heath immediately adjacent to the A31 verge. The change from U3 grassland into either Gorse-Bramble (W23) or Bristle Bent Heath (H3) appears therefore to be driven by factors other than the modelled gradient of nitrogen pollution.

Pattern 2: Is there a continuous zone of grassland parallel to the A31 along the whole length of the plateau sample area?

4.39 There is no continuous band of grassland in the zone of grassland parallel to the A31. Instead this zone is discontinuous, composed of sections with either heath, Gorse, dry acid grasslands (U3 and U1) and/or grasslands with higher pH that are base-poor to mesic. In places, these could be composed of single types of vegetation, in others two or more may occur together. The pattern observed (and sampled) does not fit with the one expected.

Review of Angold's 1997 Paper

4.40 As previously mentioned, EPR commissioned Neil Sanderson in 2003 to review Angold's 1997 paper. Of particular concern was Angold's limited consideration of potential causes affecting plant species composition other than air pollution from the road.

4.41 Sanderson investigated features and processes that are present in the New Forest landscape in association with roads that should be taken into account when considering plant species composition. His review is provided in **Appendix 2** and summarised below.

Overview of Processes

4.42 The processes set out by Sanderson that have a strong influence on vegetation patterns adjacent to roads are:

- Place in the Ecological Landscape;
- Road Construction;
- Differential Grazing Pressure;
- Fire; and
- Mowing.

Place in the Ecological Landscape

4.43 Sanderson writes that:

> "… *Until the 18th century heathland roads were rarely constructed, they were simply tracks worn across the common land on the most convenient route. In places wide bands of hollow ways can been seen, marking such old routes. These are often picked out by bands of Gorse where less leached subsoil has been exposed; such old routes can be marked by wide bands of soil disturbance.*"

4.44 These features are present in the landscape adjacent to the A31. The New Forest NPA LiDAR map shows areas of ancient tracking and the 25/6 inch to the mile maps from the 1860s show wide bands of Gorse adjacent to the straight, narrow road that became the A31; these bands of Gorse probably mark the extent of the width of the trackways that preceded the modern roads.

The vegetation surveyor (Andrew Cross) for this report noted tracking/holloways up to 30 to 40m from the modern road edge.

4.45 These tracked and rutted areas have different characteristics in comparison to the undisturbed soils; they are better-drained and are a little more fertile and consequently have the potential to support different vegetation types, and potentially shift the balance towards grassland rather than heather.

Fire

4.46 Sanderson writes that:

> "*Fire has major effects on nutrient cycling with Calluna heath. Webb (1998) in describing the effects of heath fires states that 95% of nitrogen and 20 – 30% of other principle plant nutrients in the standing crop and accumulated litter. Losses of sodium, potassium, calcium and magnesium can be replenished from precipitation within a few years but losses of phosphorus and nitrogen cannot. 20 years are estimated for the recovery of phosphorus. Nitrogen levels may take longer to recover in the absence of nitrogen fixers such as Gorse (Webb, 1998).*"

4.47 Webb's conference note on the effects of fire on heathlands is included as **Appendix 2a.**

4.48 The managed burns vary in their intensity within a burn area and between burn areas. Some soils are more productive than others and respond differently after their vegetation has been burned. Follow-up grazing of the fresh, rejuvenated or new Molinia will have differing longevity before the expansion of heathers and the decline in palatability of the Molinia. Variation in post-burn/management occur in the study area for this report.

Differential Grazing Pressure

4.49 Though most of the old A31 lies beneath the modern one, there are areas where the modern alignment has left sections or edges of the old road within the grazed landscape. These areas, for example north of the Lazy Buses layby, do support herb-rich grasslands (primarily U3 but also U1) and will occasionally have species of high conservation interest, for example Heath Violet *Viola canina* and Pale Heath Violet *Viola lactea*.

4.50 These grasslands are in effect permanent pastures adjacent to the A31 (often with Calluna nearby to form a 'grass-heath'). What is notable, however, is that these do not occur along the whole length of the A31. Taken in isolation, these richer grasslands adjacent to the road could be correlated with higher nitrogen deposition rather than what they predominantly are: relict landscape features combined with high grazing pressure.

Summary

4.51 Given the above, and the fuller note by Sanderson in **Appendix 2**, the answer to Question 2 - *is there any observable pattern (correlation) between vegetation within areas affected by the road corridor and changing air pollution concentrations/depositions with distance from the road edge?* –is that there is no observable (based on the 2018 survey) pattern correlating vegetation and concentrations of air pollutants identifiable in the results of this study..

4.52 The above is not to say that nitrogen deposition is not having an effect. The variables identified by Sanderson - soil disturbance, variable grazing, burning, mowing (and baling) - appear to have a very strong influence on the pattern/zonation of vegetation within the 200m road corridor, and especially so nearer the road. Whatever effect nitrogen deposition is having, it may not be significant; it may not be readily observable in this type of survey; and/or it may be being mitigated by the grazing and management being carried out which has the potential to remove nitrogen from the ecosystem.

Additional Observations: Nutrient Inputs and Outputs

4.53 For the purposes of the work that has been carried out to inform the HRA of the Local Plans, the lower end of the Critical Load (CL) range (10kgN/ha/year) for both wet and dry heathlands has been used to identify the prospect for a potential effect on heathland habitats to occur, as this is the most precautionary approach that can be taken for the assessment.

4.54 The critical load range for dry heaths given in APIS (based on expert opinion) is between 10 and 20 kgN/ha/year. The Review and revision of empirical critical loads and dose-response relationships (Bobbink and Hettelingh, (eds.) (2011) states that within the Load range that:

> "*Apply towards high end of range to situations where sod cutting has been practiced; apply the lower end of the range to those with low-intensity management*".

4.55 The levels of management within the Forest, and adjacent to the A31 in particular, including burning, high levels of grazing, cutting (note that this is not sod cutting but rather cutting the above ground material) and baling (thereby removing that material and its constituent nutrients from the ecosystem), are high in comparison with other heathlands with less active management and where commoner's rights are less taken up.

4.56 For comparison, research elsewhere has shown that conservation grazing of heathlands can remove nitrogen at a rate up to 2kg/ha/year[4], and where prescribed fire is used to prepare sites for forestry activities, this can result in the removal of >500kg/ha of soil nitrogen[5].

4.57 Given the above, it seems likely that the use of the 10kgN/ha/year CL to identify the potential for impacts to heathlands from traffic-related Nitrogen deposition has presented a picture that is worse than may actually manifest in reality, due to the countervailing effects of management in the New Forest.

Additional Observations: Shift from Heather Dominance to Grass Dominance

4.58 The survey data shows that Calluna is present at all the distances recorded from the road. There is no evidence in the pattern of the vegetation that there is a shift, driven by nitrogen deposition, from heather-dominated vegetation to grass-dominated vegetation. The JNCC Common Standards Monitoring (CSM) Monitoring Guidance for Lowland Heathlands (JNCC, 2004) lists 'Indicators of negative trends'. Included in this list are species that indicate eutrophication (e.g. *Urtica dioica*, high cover of coarse grasses and other herbaceous species).

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[4] Wallis de Vries, M.F., Bakker, J.P. & van Wieren, S.E. (1998). *Grazing and Conservation Management*. Conservation Biology Series. Kluwer Academic Publishers, Dordrecht, the Netherlands.

[5] Jurgensen M.F., Harvey A.E., Graham R.T., Page-Dumroese, D.S., Tonn, J.R., Larsen, M.J. & Jain, T.B. (1997) *Impacts of timber harvesting on soil organic matter, nitrogen, productivity, and health of inland northwest forests*. Forest Science, 43: 234–251.

None of the species of eutrophication were present in the quadrat samples or noted in the Study area. *Deschampsia flexuosa* was not recorded anywhere in the sample area.

4.59 It appears that the H3 ecosystem is intact and is cycling through its processes driven predominantly by management (most importantly burning) and grazing.

4.60 Regarding the relative abundance of Calluna, which was recorded as percentage cover, the statistical analysis has shown that there is no significant correlation between Calluna cover and distance from the road; i.e. Calluna cover appears to be independent of distance from the road. This implies that there is no shift from heather dominated vegetation to grass-dominated vegetation because of a potential nitrogen deposition gradient. Where there a shift from heather to grass driven by nitrogen deposition, there would be a strong correlation between Calluna abundance and distance from the road.

Additional Observations: Lichen Abundance

4.61 Neither U3 nor H3a/c are lichen-rich vegetation types. We observed that *C. portentosa* increases in the older vegetation stands, which is characteristic of the species, and that these stands tend to be further from the road. Abundance of other *Cladonia* spp. showed no significant association with distance.

Additional Observations: Calluna Damage

4.62 For Calluna damage, our assessment referred to the NCC Report *Heather damage: a guide to types of damage and their causes* (MacDonald, 1990).

4.63 Three types of damage were recorded during the survey work:

- 1 –Dead long-shoots;
- 2 – Dead branch/branches but most of plant still alive; and
- 3 – Whole *Calluna* plant dead.

4.64 The damage type 1 was widespread across the site. It was generally mostly rare in each quadrat sample (i.e. one to a few long shoots). Searches beyond the study showed that this type of damage was equally present.

4.65 MacDonald writes that:

> "*It is not unusual for the apex of the terminal shoot to die over winter, even in relatively sheltered situations. Two or more of the end of season short shoots will be transformed into new long-shoots in the following spring. This produces the characteristic branching pattern of heather which maintains the density of shoots in the canopy as the heather bush grows larger*".

4.66 It may be that the type 1 damage is part of the life and growing of *Calluna*.

4.67 Type 2 damage was uncommon in the samples. Most cases on close examination appeared to be physical damage to the plant (trampling).

4.68 Type 3 damage was recorded rarely. The plants appeared to be suffering from water stress. MacDonald describes the symptoms were observed on the survey:

> "*after a period of water stress damaged foliage turns brown orange and dies, then gradually turns greyish-brown*."

4.69 This type of damage appeared to coincide with very shallow soils.

4.70 There is no correlation between distribution of any of the three types of *Calluna* damage and distance from the A31.

4.71 A process for describing and assessing damage to *Calluna* in the New Forest is needed as there are many potential causes of damage, most of which have no readily available description for a surveyor to follow.

Results: B3056 Control

4.72 Two transects (of 5 quadrats each) were surveyed perpendicular to the B3056 to the west of Ferny Crofts. Both transects were on the north eastern side of the road. The vegetation type recorded here was predominantly Humid Heath H2c *Ulex minor – Calluna vulgaris* heath, which is different to the H3 heaths of the plateau adjacent to the A31.

Woodland Desktop Study

4.73 The full desktop study review of potential impacts on the Annex 1 woodland habitats of the New Forest was carried out by Neil Sanderson. It was based on a review of records and literature and many years of personal experience of the author surveying in the New Forest. The full review is included as **Appendix 3.**

4.74 In summary, the assessment concludes that it is very difficult to see any current impact on the general vegetation on New Forest woodlands from aerial pollution at present, such that any impacts that are occurring are very subtle and hard to untangle from the effects of management and climate influences. This would appear to accord with the low ammonia levels that currently prevail across the New Forest due to lack of commercial intensive agriculture (**Map 5.2**). One known exception is where it appears that intensive car park use has led to localised effects. Existing road-related effects are evident in the form of reduced species richness of lichens on tree trunks adjacent to the road edge, although the impact appears to be largely due to the physical deposition of road dust, as the impact drops off very quickly away from the road edge.

4.75 Notwithstanding these observations, the predicted possible increases in ammonia do need to be considered, as if sufficiently high could have the potential to affect the more sensitive lichen species. In view of the importance of the lichen assemblage, Sanderson recommends a monitoring method that would detect any changes that occurred in roadside assemblages. This monitoring has been included in **Section 6** below.

4.76 Mitigation for impacts on woodland habitats is possible, but would be very difficult to achieve in many instances, as it would rely on the provision of shelterbelt planting, for which space does not always exist or would require the removal of more valuable habitat.

Other Non-Woodland Annex 1 Habitats

Aim of this Study

4.77 The aim of this element of the study was to assess whether the non-woodland Annex 1 habitats for which the New Forest was designated are in, or are likely to be in, any of the areas of the Forest where the Local Plans make a significant contribution to forecast exceedances in traffic-related air pollution. This is so that they can be identified for the purposes of future monitoring.

4.78 To assist with this, raw AQ modelling data was obtained from AQC and used to produce a series maps that show only those areas where the Predicted Environmental Concentration (PEC) of each N related pollutant in 2036 is predicted to exceed 100% of the relevant CL for each habitat type, **and** where the contribution from the Local Plans (the 'Process Contribution' or 'PC') is predicted to exceed 1% of the CL. The maps showing these areas are provided as **Maps 7.1** to **7.4** for each pollutant type and are discussed in more detail in **Section 7** below.

4.79 The combined spatial area of all of the exceedance zones from **Maps 7.1** to **7.4** were then overlain onto the HBIC Broad Habitats Data, shown on **Map 7.5.** This map was then examined to identify areas of 'short' (i.e. non-wooded) habitats within the exceedance zones, to enable those areas to be searched for records of species characteristic of other Annex 1 habitat types. The areas for which data was searched are shown on **Map 6.1**, and they are also proposed in **Section 6** below for future monitoring.

4.80 The method used was to refer to the vegetation descriptions in the New Forest SAC Management Plan (2001) and their correlation with Annex 1 Habitats to identify important species characteristic of those Habitats. The distribution of those species was examined with reference to the BSBI database for vascular plants. In the absence of sufficiently accurate NVC mapping data, this is considered to be the most effective way to identify the presence or potential presence of Annex 1 habitats.

4.81 The Annex 1 Habitats reviewed here are:

Habitat Code	**Habitat Title**
3110	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae);
3130	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea;
7150	Depressions on peat substrates of the *Rhynchosporion*;
4010	Northern Atlantic wet heaths with *Erica tetralix*;
4030	European dry heaths;
6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caerulae);
7140	Transition mires and quaking bogs; and
7230	Alkaline fens.

Results

Area 1: Lyndhurst – Boltons Bench and Fox Hill Area

4.82 The monitoring area extends 200m from the edge of the A35 between Boltons Bench and Dunces Arch. The area occupies parts of the following 1km squares: SU3008 and SU3108.

4.83 The following non-woodland Annex 1 habitats are, or could be, in the monitoring area:

Habitat Code	Habitat Title
4010	Northern Atlantic wet heaths with *Erica tetralix*;
4030	European dry heaths; and
6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caerulae).

4.84 There are records for Pillwort (indicative of Annex 1 3130) and Marsh Clubmoss (indicative of Annex 1 7150) in the SAC close to the monitoring area in lower lying, wetter ground to the east and north east of the monitoring area. The monitoring area is on higher, drier ground and it is unlikely that these species will be present in the area and thus the Annex 1 3130 and 7150 habitats are very unlikely to be present.

4.85 Chaffweed and Yellow Centaury have been recorded from areas north of the A35 (for example, the golf course, which is outside the SAC; Rushpole Wood and Dunces Arch Inclosure). Both these species are indicative of Annex 1 3130 habitat though there are no records for them south of the A35 in the monitoring area. The area is well botanised (for example the NCC and English Nature office used to be here) and the absence of records in the monitoring area indicates, again, that Annex 1 3130 is unlikely to be present.

4.86 There are no permanent ponds in the monitoring area and thus Annex 1 Habitat 3110 is not present.

4.87 There are no mire systems present in the monitoring area and thus Annex 1 habitats 7140 and 7230 are not present.

4.88 There are areas of lichen-rich heath in and adjacent to the monitoring area (personal experience of surveys with N. Sanderson).

Area 2: Setley Plain

4.89 The monitoring area extends 200m from the edge of the A337 into Setley Plain. Most of the Forest SAC here lies to the west of the A337 with a small area of the SAC to the east. The area occupies parts of the following 1km squares: SU3000 and SZ3099.

4.90 Most of the monitoring area is on the high ground of the plain. There are no substantial natural wetlands present.

4.91 The following non-woodland Annex 1 habitats are in the monitoring area:

Habitat Code	Habitat Title
4030	European dry heaths.

4.92 Wet Heaths (4010) and Molinia Meadows (6410) are unlikely to be present on the Setley Plain plateau.

4.93 There are no records for Pillwort, Chaffweed and Yellow Centaury (all indicative of Annex 1 3130) indicating that this habitat is very unlikely to be present on the Plain.

4.94 There are no permanent ponds in the monitoring area and thus Annex 1 Habitat 3110 is not present.

4.95 There are no mire systems present in the monitoring area and thus Annex 1 habitats 7140 and 7230 are not present. There are neither Intermediate-leaved Sundew nor Marsh Clubmoss records (indicative of Annex 1 7150) from Setley Plain indicating that 7150 habitat is absent.

4.96 It is not known whether any lichen-rich heath is present as to our knowledge the area has never been surveyed for lichens.

Area 3: Markway Bridge to Holmsley Inclosure

4.97 The monitoring area extends 200m from the edge of the A35 on its north-western side and includes the following (starting at the northern end): valley draining north to Markway Bridge; Markway Hill; Spy Holms and onto Station Road above the Avon Water.

4.98 The area occupies parts of the following 1km squares: SU2403; SU2402; SU2401; SU2301 and SU2300.

4.99 This is the most topographically complex of the monitoring areas and includes land from plateau down to valley bottoms.

4.100 The following non-woodland Annex 1 habitats are in or very likely to be in the monitoring area:

Habitat Code	Habitat Title
4010	Northern Atlantic wet heaths with *Erica tetralix*;
4030	European dry heaths; and
6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caerulae).

4.101 There are records for Pillwort, Chaffweed and Yellow Centaury (all indicative of Annex 1 3130) close to the monitoring area indicating that this habitat could be present in the area.

4.102 There are no permanent ponds in the monitoring area and thus Annex 1 Habitat 3110 is not present.

4.103 There are two valleys in the monitoring area. Marsh Clubmoss (indicative of Annex 1 7150) has been recorded from close to the monitoring area and thus 7150 habitat could be present in the monitoring area.

4.104 It is not known whether any lichen-rich heath is present in the monitoring area as to our knowledge the area has never been surveyed for lichens.

Conclusions and Recommendations

Dry Heaths Survey

4.105 Landscape history and management exert a very strong influence on vegetation types.

4.106 There appears to be no clear signal present in the data collected that there is any significant impact on the Annex 1 dry heaths habitat occurring adjacent to the A31 as a result of traffic-related nitrogen pollution. This could be because the effects of management upon the vegetation is obscuring evidence, or because management is counteracting the effects of nitrogen deposition.

4.107 Any future survey and monitoring need to take into account the Sanderson model (**Appendix 2)** and zonations associated with roads. It will not be possible to isolate changes in vegetation that occur as a result of traffic-related air pollution without controlling for the effects that are determined by these road-related zones.

4.108 Due to the high degree of variability in habitat patches across the Forest, baseline information for specific proposed monitoring areas is needed in order to enable future comparisons and to contrast vegetation changes over time. In particular, current habitat mapping available from HBIC and other sources is of insufficiently high resolution (and appears to lack ground-truthing) to be able to facilitate mapping of the location and spatial distribution of Annex 1 habitat types.

4.109 There is a pressing need for specific information on how the vegetation in Annex 1 habitats responds to the management/grazing cycle as carried out in the New Forest (the process is well understood but there is no site-specific information). This is especially important as this is potentially a valuable means of mitigating potential changes to vegetation arising from increases in nitrogen deposition (see **Section 7**).

Annex 1 Woodland Habitat Assessment

4.110 Although the Annex 1 woodland habitat types themselves are considered unlikely to be significantly affected by traffic related air pollution associated with the Local Plan alone or in combination, the Internationally important assemblage of epiphytic lichens that could potentially be at greater risk, particularly from possible increases in ammonia levels arising from future traffic. A lichen monitoring scheme should be established to identify potentially significant changes to lichen assemblages in old-growth woodlands. The structure of the proposed monitoring is discussed in **Section 6**.

Other Non-Woodland Annex 1 Habitat Types

4.111 The examination of forecast pollution levels in 2036 described above has been used to identify areas where 'short' (i.e. non-woodland) habitats potentially including Annex 1 SAC habitats may occur in areas that are forecast to experience an exceedance where the Local Plans are making more than a trivial contribution (>1% of the CL). These such areas have been identified for future monitoring (**Map 6.1**).

4.112 The AQC modelling produced to date shows areas where predicted ammonia levels in 2036 are forecast to be in exceedance of 1 microgram per m^3, the point at which sensitive lichen species could be affected.

4.113 Nothing is known of the lichen distribution in the non-woodland habitats in Monitoring Areas 2 and 3. In the first instance, a lichen assessment of these areas needs to be carried out to identify whether any lichen-rich areas are present and at what point the burn cycle is at (lichens are very dependent on the burn cycle and diversity/abundance is strongly related to age within the burn cycle).

4.114 Vascular plant vegetation has a critical level for ammonia of 3 micrograms per m^3. Whilst this hasn't been modelled, given the existing very low levels of Ammonia throughout the Forest (see **Map 5.2**) if in 2036 any areas do exceed the 3 microgram limit, they are likely to have a very small footprint and be well within the spatial extent of the 1 microgram limit. It is unlikely therefore that there will be any significant impact on vascular plants within these habitats arising from Ammonia emissions within the Forest.

4.115 We propose that potential impacts arising from increases in nitrogen deposition be investigated with a monitoring system, which is outlined in **Section 6**.

5. OVERVIEW OF PROPOSED MONITORING & MITIGATION STRATEGY

The Need for Monitoring and Mitigation

5.1 From the analysis and discussion presented above, our view is that there is currently no clear evidence of any traffic-related nitrogen pollution impact on the qualifying Annex 1 habitats of the New Forest SAC, and by extension the other International designations.

5.2 However there remains the possibility that management measures such as burning and grazing are either masking such impacts, or that they are counteracting them (through the removal of nitrogen from the ecosystem as detailed above in **Section 4**), with the implication being that the cessation of such management (either wholly or in localised areas of pollution exceedance), although highly unlikely, would enable negative changes to take place.

5.3 AQC's 2018 Air Quality Modelling, and BSG Ecology's 2018 Review of that information, detail the predicted changes to air quality as a result of all forecast sources of air pollution between 2015, 2026 and 2036, and have identified additional areas of exceedance of CLs. The anticipated percentage changes in each type of pollutant between 2015 and 2036 are shown on **Maps 5.1, 5.3** and **5.4.**

5.4 Past levels of air pollution generally across the New Forest as a whole would have been worse (particularly in relation to acid deposition). Further, the temporal extent of future increases in nitrogen pollution may be limited by the proposed forthcoming 2040 ban in the sale of new conventional diesel and petrol vehicles. Our assessment work did not identify any evidence to suggest that an adverse effect on the integrity of SAC habitats is occurring, or that it is likely to occur as a result of development coming forward within the Local Plan acting either alone or in combination with other pollution sources.. This is particularly so in view of the countervailing effect of management that is already occurring across the New Forest and which is very is likely to continue into the future.

5.5 However, the possibility for localised damage to occur at the roadside as a result of increased levels of nitrogen pollution cannot be wholly precluded, and consequently we recommend that steps are taken to monitor for the early warning signs of unexpected change, so that appropriate mitigation measures can be brought to bear if necessary. This is only likely to be the case in areas where management such as grazing and burning is in abeyance, or for particular habitat types where such management does not occur.

5.6 Of particular note is the possibility that future improvements in vehicle technology designed to reduce the emission of NOx (primarily for human health reasons), may inadvertently increase the levels of ammonia emitted from roads traversing the New Forest. Ammonia is a form of reduced nitrogen that is generally considered to have greater potential to cause damage to vegetation through eutrophication than oxidised forms of nitrogen (which make up the other component parts of total nitrogen deposition).

5.7 At present, significant comfort can be taken from the fact that the most sensitive indicators of ammonia impacts, epiphytic lichens, do not appear to show any signs of being negatively affected according to the desktop study carried out by a leading New Forest expert, Neil Sanderson (**Appendix 3**) (with the exception of one possible localised example of a busy camp site car park).

5.8 This is likely to be a reflection of the current very low levels of ammonia within the Forest, which is itself a reflection of the lack of commercial agriculture. See **Map 5.2** for existing background levels of ammonia within the New Forest obtained from APIS – at present all 5km grid squares within the New Forest itself are shown as having less than the 1 $\mu g/m^3$ CL for sensitive epiphytic lichens, and there is nowhere within the New Forest experiencing the 3 $\mu g/m^3$ CL for vascular plants.

5.9 AQC (2018) acknowledge that there is uncertainty over the likely future levels of ammonia (paragraphs 3.9 and 3.19 of their report). It also seems likely that future trends in ammonia emissions from changing vehicle technology will apply to traffic originating from sources other than the Local Plans.

5.10 Consequently, we recommend that a system is put in place to monitor future changes in the New Forest, to enable action to be taken in the future as soon as early warning signs begin to be detected.

Recommendations for Monitoring and Mitigation

5.11 Following on from the above, our recommendations for monitoring and mitigation fall into three distinct strands:

1 – Addressing the current information deficits that have constrained this study and which will constrain any future monitoring programme unless overcome. The measures required to achieve this are outlined in **Section 6** below;

2 – Establishing a robust monitoring framework to detect the early warning signs that Annex 1 habitats within the Forest are being affected by traffic-related air pollution, so that mitigation measures can be brought to bear if required. Our recommendations for monitoring are outlined in **Section 6** below; and

3 – Developing a 'menu' of costed mitigation options, that could be deployed in the event that monitoring showed them to be required in the future. This is discussed in **Section 7** below.

5.12 Notwithstanding the above recommendations, it should be borne in mind that prevention is better than cure. Ricardo AEA (2016) identifies traffic-related measures that are designed to reduce pollutant levels in sensitive locations. It is noted that 'traffic emissions generated at any given site are essentially determined by three factors:

- The amount and type of vehicles flowing past a site;
- The way vehicles are driven (e.g. their speed) and the level of congestion; and
- The emissions performance of vehicles, which is dependent on age and technology.

5.13 In this respect the most powerful measures to prevent harm to the New Forest SAC habitats and others could be comprised of:

- Reducing vehicle traffic through the New Forest itself (e.g. through re-routing of trips, promotion of public transport etc);

- Improving the efficiency of the conveyance of traffic through the New Forest, to minimise idling vehicles and congestion in areas that support sensitive habitats;
- Encouraging walking and cycling instead of driving for residents and visitors to the New Forest; and
- Encouraging the use of low emission vehicles such as electric or hybrid vehicles.

5.14 The measures listed above fall outside of EPR's professional competence as an ecological consultancy, and so we advise NFDC and NFNPA to secure advice on this from others better placed to advise (i.e. a transport expert).

6. MONITORING

Introduction

6.1 The fieldwork and analysis of air quality effects on New Forest habitats that has been undertaken and reported on in this report should be seen as a useful starting point for monitoring habitats in the future.

6.2 The methods used for ongoing monitoring should be consistent/equivalent between years, to ensure the results are comparable with each other. Refinements to the method will be informed by ongoing research.

6.3 The text included in this section provides:

- Recommendations to **address immediate information deficits** that will enable a more effective monitoring effort to be planned and implemented (N.B.: These will be 'one off' costs at the start of the monitoring programme, rather than monitoring activities repeated at regular intervals;

- **A monitoring strategy for 'short' Annex 1 Habitats** including wet and dry heathlands; and

- **A monitoring strategy for 'tall' Annex 1 habitats** (Woodlands), which focuses on the recording of epiphytic lichens as both the most sensitive element of woodland habitats to air pollution, and one that is particularly important for the New Forest.

6.4 The monitoring of 'short' and 'tall' Annex 1 habitat types are addressed separately because each category of habitats is subject to a different 'deposition velocity' for nutrient nitrogen deposition. This is because 'tall' habitats such as woodland have a greater surface area in contact with the air than short habitats, and consequently ambient pollution tends to deposit to them at a greater rate. This is independent of the sensitivity of the particular habitat concerned to the pollutant in question (which is measured by the CL).

6.5 An example of a more intensive longer-term study, at Ashdown Forest SAC is also given below. Some aspects of this may be of interest in terms of demonstrating the efficacy of more detailed analysis of plant material and soils requiring sample collection and laboratory analysis, although the emphasis of monitoring efforts on the New Forest will be different.

Addressing Immediate Information Deficits

Detailed NVC Mapping of Monitoring Areas

6.6 As outlined above in **Section 4**, the precision of this survey work and the ability to plan sampling was significantly constrained by the lack of detailed vegetation mapping (NVC) data for the areas concerned.

6.7 Consequently, it was not possible to determine in advance of visiting the site, whether or not a variety of Annex 1 habitats were actually present in a given roadside area – topography, hydrology and broad habitat information had to be used to formulate an educated guess.

6.8 It will be essential to future monitoring work that detailed NVC mapping is available for the areas proposed to be monitored, both for the purposes of planning the monitoring itself, and to enable changes in vegetation community cover to be recorded.

6.9 As shown on Maps **6.1** and **6.2**, there are a total of **7 locations** identified and recommended for monitoring (3 that focus on 'short' habitats, and 4 that focus on 'tall' habitats).

6.10 For the monitoring methods that we recommend (set out in more detail below), the area within these that will need to be subject to NVC mapping is likely to be approximately between 6-10ha in extent.

6.11 Assuming a 10ha area for each of the 7 monitoring locations, we would estimate that it will take between **14 and 21 days** to NVC map all 7 locations in the field and then digitise the habitat maps into a Geographical Information System (GIS) layer for future use. This cost should not need to be repeated during the Local Plan period to 2036.

Lichen Assessment of Proposed 'Short' Habitat Monitoring Areas 2 and 3

6.12 As noted above in **Section 5**, very little is known about the distribution of sensitive and important lichen species in monitoring areas 2 and 3 shown on **Map 6.1**. This baseline position will need to be established prior to the onset of monitoring in these areas. At present, it is assumed that the botanist undertaking the above recommended NVC mapping would be able to carry out this work during the NVC survey, and so no additional time allowance would be needed (although this may push the time estimate towards the upper end of that given above).

6.13 If, however, the botanist carrying out the NVC mapping is insufficiently expert in lichen identification (a specialist skill that not all botanists possess), then an additional time allowance would be required.

Example of Habitat Monitoring - Ashdown Forest SAC

6.14 Ecus (2016) were commissioned to undertake a long-term vegetation and air quality monitoring project within Ashdown Forest SAC. The project was carried out with support from Air Quality Consultants Ltd. Reference has been made to this study to help devise the monitoring study for the New Forest SAC habitats.

6.15 The elements of the study included vegetation monitoring and air quality monitoring. The vegetation monitoring included the following elements:

- *Monitoring the extent of heathland within the SAC (*aerial mapping*);*
- *Surveying the structure and composition of the heathland (*sampling within quadrats along transects*); and*
- *Investigating the nitrogen and amino acid concentrations in soil and vegetation (*using samples taken in quadrats along transects*).*

6.16 Full details of the methodologies employed are provided in a separate methodology documents provided to Wealden Council (Mott MacDonald, 2013; Ecus Ltd, 2014; AQC, 2014), and these have been taken into account in developing the proposed methodology for the New Forest.

Monitoring Strategy for 'Flat' Habitats

Locations

6.17 **Maps 7.1-7.4** were examined to identify locations in which total air pollution (the PEC) is expected to exceed CLs in 2036 for each pollutant and habitat type, and to which the Local Plans are expected to contribute at least 1% of the CL.

6.18 These individual exceedance areas were then combined to create a single GIS layer, and compared against broad habitat data for the New Forest (**Map 7.5**) to identify areas where exceedances were predicted across areas that can be expected to support Annex 1 SAC habitats (particularly heathlands which are more easily monitored).

6.19 The main roads that are expected to create exceedances of CLs, and to which the Local Plans are making a contribution that is more than trivial (i.e. >1% of the CL) are:

- The A35 west and east of Lyndhurst; and
- The A337 North and South of Lyndhurst.

6.20 Three particular areas were identified, and these are shown on **Map 6.1**. A desktop study has already been carried out into each of these areas to evaluate their potential for supporting Annex 1 habitats that are not shown overtly on existing mapping data (see **Section 4**).

6.21 It should be noted that although all three proposed monitoring areas are mapped as containing heathland, they are located on different geologies to the study site.

Survey Strategy

6.22 It will be very important to calibrate the proposed monitoring method so that sufficient data is generated to enable robust statistical analysis of the results to be carried out, but not to over-collect data that is of limited use but which would otherwise greatly and unnecessarily increase the time and cost of carrying out long-term monitoring.

6.23 We consider that a transect-based approach would be most useful as this enables the direct comparison of data with distance from road edge. However, as the primary purpose of monitoring will be to compare results between years (in order to identify change), the sampling strategy need only ensure that the sample size at each distance from the road edge is sufficiently large to enable statistical tests to be carried out to identify changes between years at each distance from the road edge.

6.24 In summary, at this stage we would recommend:

- Each of the three monitoring areas to be subject to three individual transects, with their start and end points fixed to enable the same vegetation to be sampled each year;
- Each transect to have x10 quadrats (1m x 1m) collected parallel to the road edge at each of three distance intervals. We would suggest that the distance intervals are taken at or around the 45m, 90m and 180m points from the road edge. These intervals are chosen because they:

- Omit ‘Zone 2’ as identified by Sanderson (**Appendix 2**) where roadside management significantly interferes with results; and

- Have their outer sample point beyond the area within which guidance (DMRB) and research (Laxen & Marner, 2008) indicates that traffic related air pollution will be significant.

- For each quadrat sampled, the information collected should include: cover and abundance of lichen species, heather to grass ratio, and a measure of heather damage; and

- Samples should also be taken of soil and foliar material to test for key soil nutrients. These should include soil nitrogen and also phosphorous in view of the confounding effect that animal dung appears to have had on past research in the New Forest (Angold, 1997). Plant foliar nitrogen levels should also be tested.

6.25 Subject to changes that may arise following consultation with Natural England on the above methodology, we would estimate that the above methodology would take in the region of 6 days to complete, plus a further 2 days to write up the results (i.e. 8 days in total).

6.26 Given that vegetation changes tend to be very gradual, we would suggest a recording interval of 3 years (i.e. 6 monitoring events in total between now and 2036). It will be important to carry out the first monitoring survey as soon as possible, to establish a baseline against which to monitor future changes in these new locations.

Monitoring Strategy for ‘Tall’ Habitats

6.27 As above, the combined exceedance areas presented on **Maps 7.1** to **7.4** were examined to identify locations in which total air pollution (the PEC) is expected to exceed CLs in 2036 for each pollutant and habitat type, and to which the Local Plans are expected to contribute at least 1% of the CL. Particular attention was paid to ammonia. As with short habitat types, the key roads highlighted were the A35 and A337 (each on both sides of Lyndhurst).

6.28 This information was then compared to Sanderson’s Map of Lichen-rich Old Growth Metasites within the New Forest (provides in **Appendix 3**). Epiphytic lichens will be the focus for the recommended monitoring of potential impacts on woodland Annex 1 habitats, since they are the most sensitive group to air pollution and also of International importance as an assemblage.

6.29 Sanderson (**Appendix 3**) identified four specific locations where predicted exceedances of the 1 $\mu g/m^3$ CL for ammonia coincides with the location of Lichen-rich Old Growth Metasites and these are shown on **Map 6.2**. It is these locations that are recommended for future monitoring.

6.30 Sanderson has suggested utilising a monitoring methodology developed by Wolseley *et al.* (2006). This methodology requires the surveyor to look for particular ‘indicator’ species of lichen that live on the twigs and trunks of trees in areas being monitored, that have varying tolerances to air pollution.

6.31 The monitoring method designed by Wolseley has since been developed further by APIS for the purposes of enabling greater participation. A field manual and a downloadable app are available from the following website:

http://www.apis.ac.uk/nitrogen-lichen-field-manual

6.32 We recommend that the monitoring method deployed for woodland habitats at the New Forest be based on this APIS version of the method, as it will allow results to be uploaded into a wider National dataset that will help to improve understanding of the impacts of nitrogen and ammonia pollution.

6.33 In summary, the method requires the surveyor to identify a minimum of 5 or more Oak or Birch trees in the sample area, and then to follow the prescribed methodology to identify the lichen species present on the twigs and trunk of the subject trees in order to gauge ambient air pollution levels. Results are then recorded and used to calculate a Lichen Indicator Score (LIS) and submitted to APIS.

6.34 In this instance, it will be important to understand the penetration of ammonia into woodlands (if at all), and consequently we would recommend that, similar to the methodology for tall habitats, a transect is taken at each side of the road, and trees are picked for census at prescribed distance intervals from the road edge.

6.35 In this case, unlike with short habitats, burning, grazing and dunging etc. and the resultant zonation will not be a factor, and so the first distance point on each transect should be the road edge. This will enable comparison with trees further in to the woodland edge.

6.36 In order to carry out the above method on both sides of the road, to include census of trees between 3 and 4 distance intervals on each side, would take around 2 days per monitoring location (i.e. 8 days in total per monitoring event).

6.37 As with the short habitats, given the slow pace of change, we would recommend undertaking monitoring every 3 years (with the first event to take place as soon as possible in order to establish a baseline for each monitoring area). This will mean that there will be 6 monitoring events in total between now and 2036.

Other Important Requirements and Notes

Monitoring of Air Pollution Itself

6.38 At present, forecast future levels of traffic-related air pollution across the New Forest are heavily reliant upon modelling predictions. These models, in turn, are reliant upon assumed background levels of pollution drawn from APIS. The assumed background levels of air pollution are again, in turn, informed by empirical readings of air pollutant concentrations taken from sources such as the 21 diffusion tubes placed in Lyndhurst, and at three other locations adjacent to roads assumed to be representative of roads passing through ecological areas of the New Forest (see paragraph 3.3 of the AQC 2018 Report).

6.39 In view of the apparent uncertainty inherent in the modelling (e.g. in relation to forecast ammonia emissions), it will be important to understand whether the actual air pollutant concentrations are comparable with those forecast – not just across the New Forest as a whole, but specifically at the locations being subject to monitoring for vegetation change. If this is not done, then any observed changes in vegetation could be wrongly attributed to air pollution.

6.40 The costs of best methodology for carrying out such measurements of air pollutant concentrations are not included in this monitoring strategy, as it is not within EPR's field of expertise as ecologists. A suitably experienced air quality consultant will need to be consulted.

In Combination Impacts to Which the Local Plans are Not Making a Significant Contribution

6.41 It should be noted that the abovementioned 7 proposed monitoring locations have been deliberately targeted towards areas where there is both expected to be an exceedance by the PEC of the relevant CL, and **also** where the Local Plans (the PC) are making at least a contribution of 1% of the CL.

6.42 The 1% threshold for the PC has been chosen because it provides an objective means to determine what might be a meaningful (as opposed to trivial) contribution toward any predicted air quality problem.

6.43 The 1% threshold is enshrined in guidance on assessing air quality impacts provided in 'the Air emissions risk assessment for your environmental permit'[6], issued by DEFRA and the Environment Agency.

6.44 With regards to screening out insignificant PCs, the guidance advises the following when there are SPAs, SACs (Special Areas of Conservation), Ramsar sites or SSSIs:

> *"If your emissions that affect SPAs, SACs, Ramsar sites or SSSIs meet both of the following criteria, they're insignificant - you don't need to assess them any further:*
>
> *the short-term PC is less than 10% of the short-term environmental standard for protected conservation areas*
>
> *the long-term PC is less than 1% of the long-term environmental standard [the CL] for protected conservation areas"*

6.45 The DEFRA - Environment Agency guidance proceeds to note that "*For SPAs, SACs and Ramsar sites, you need to consider the 'in combination' impact of all permissions, plans or projects that affect the site*" – although it provides no indication of how this could be undertaken.

6.46 The DEFRA guidance consolidates and supersedes the Environment Agency's 'Horizontal Guidance Note H1 Annex F', which provides further useful background on the rationale behind the application of the 1% threshold:

> *"Process contributions can be considered insignificant if:*
>
> *The long term process contribution is <1% of the long term environmental standard" [i.e. the Critical Load or Level];*

[6] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

"The long term process contribution 1% threshold is based on the judgements that:

It is unlikely that an emission at this level will make a significant contribution to air quality since process contributions will be small in comparison to background levels, even if a standard is exceeded;

The proposed 1% threshold is two orders of magnitude below the standard and provides a substantial safety margin to protect health and the environment."

6.47 This position is supported by a position statement issued by the Institute of Air Quality Management (IAQM) on the 'Use of a Criterion for the Determination of an Insignificant Effect of Air Quality Impacts on Sensitive Habitats' (2016), which provides:

"The EA recognised early in its process of developing guidance that there would always be a level of emission from an installation such that its impact would be so small as to constitute an 'inconsequential effect', when considered in isolation or in combination with the background or other sources. It chose to set this level at 1% of the relevant criterion, which is typically the critical level for vegetation or the critical load for the habitat being considered… a level that was considered so low as to be unequivocally in the 'inconsequential' category. In other words, this can be reasonably taken to mean that an impact of this magnitude will have an insignificant effect….

"it is the position of the IAQM that the use of a criterion of 1% of an assessment level in the context of habitats should be used only to screen out impacts that will have an insignificant effect. It should not be used as a threshold above which damage is implied and is therefore used to conclude that a significant effect is likely. It is instead an indication that there may be potential for a significant effect, but this requires evaluation by a qualified ecologist and with full consideration of the habitat's circumstances. The criterion also is intended to apply to an individual source and is not intended to be applied to multiple sources 'in combination'."

6.48 A similar interpretation of the 1% threshold was put forward in the Inspector's Report on APP/D0840/A/09/2113075 concerning land at Rostowrack Farm, Cornwall, which upheld an appeal against the refusal of planning permission for a waste to energy plant. The Inspector rejected Cornwall Council's position that adverse air quality impacts upon a nearby SAC could not be discounted:

"Mr Boyle's opinion has seemingly confused the separate concepts of de minimis and trivial effects, concluding that if an effect is not de minimis it must be considered in combination with other effects. In so doing he has omitted the crucial consideration whether the effect, albeit not de minimis, is trivial. It is difficult to call it anything other than trivial when the 1% threshold is set at 100 times below the level below which significant harm would not be caused.

It is for this reason that Mr Barrowcliffe describes it as a test of inconsequentiality and the EN Habitats Regulations Guidance Note 3 provides that likely significant effects exclude trivial or inconsequential effects."

6.49 In summary therefore, the proposed monitoring locations specified above in this **Section 6**, and the potential mitigation options outlined below in **Section 7**, have deliberately been targeted towards those locations where an exceedance of the CL by the predicted PEC is likely to be the subject of a material contribution by development coming forward with the Local Plans.

6.50 Two important considerations therefore are that i) there may be other significant contributors towards the predicted future exceedance areas, and ii) there are other predicted exceedance areas within the New Forest (for example along the A31), toward which the Local Plans are not predicted to make anything other than an ‘inconsequential’ contribution in terms of air pollution. The NFDC and NFNPA may therefore wish to consider further the extent to which development outside of their Local Plan areas should contribute towards measures to address the impacts of air pollution. This information can only be provided by an air quality modeller (e.g. AQC).

7. MITIGATION

Introduction

7.1 At this stage, for the reasons outlined above, no specific mitigation measures are recommended.

7.2 This section however outlines the potential components of any mitigation strategy that could be brought to bear should ongoing recommended monitoring detect any negative effects resulting from traffic related air pollution. The appropriateness of all of the measures set out within this section would need to be carefully considered in view of the conservation objectives of each of the designated sites, and the characteristics of any affected area(s) in terms of the habitats that it supported and the potential consequences of the intervention proposed.

7.3 Ricardo AEA (AKA Smithers *et al*.) (2016) identifies a number of habitat management measures that can be used to mitigate the impacts of airborne pollutants. Of the measures suggested, the following two are of potential relevance:

- Shelterbelts: Wooded shelterbelts can capture particulates but the role of trees 'in preventing the spread of gaseous pollutants is less clear, although there is some evidence to suggest that they act as a physical barrier to NO2 transport, changing dispersal patterns rather than taking up the pollutant'. The use of shelterbelts will need to take into account the conservation objectives for the International site and cannot be at the expense of those habitats that are interest features within the designated sites.
- Habitat management: It is possible that adoption of certain management practices could result in the removal of nitrogen from a site, thereby reducing the effect of nutrient nitrogen deposition. It is, for example, evident from the SSSI condition assessment for the New Forest that land management is an important factor in determining present condition.

Quantifying the Habitat Types Potentially Affected

7.4 **Maps 7.1** to **7.4** present the modelled scenario for 2036 Combined for Annual Mean NOx, N Deposition (Grassland / Short Habitats), N Deposition (Woodlands / Tall Habitats) and Ammonia, respectively.

7.5 **Map 7.5** shows the 2036 Combined in-combination exceedance areas for all pollutants laid upon the habitats map (HBIC Broad Habitats data). Since these Broad habitat types may include some of the Annex 1 habitat types within the zone of influence, this provides the maximum area of each Annex 1 habitat type that may be affected by air pollution from traffic, and require some form of mitigation applied should future monitoring pick up any signals of damage.

7.6 In reality the areas of Annex 1 habitat affected are likely to be much smaller but without detailed habitat mapping cannot be quantified in detail**.**

7.7 The Broad habitat data and potentially equivalent Annex 1 habitat components is summarised in **Table 7.1.**

Table 7.1: Summary of Broad Habitat Areas Within Combined Predicted Exceedance Areas.

Broad Habitat Type*	**Area (ha)**	**Potential Annex 1 Habitat Component****
Acid grassland	38.89	6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)
Bracken	0.53	None
Broad-leaved woodland	194.34	9120 Atlantic acidophilous beech forests 9130 *Asperulo- Fagetum* beech forests 9190 Old acidophilous oak woods
Coniferous woodland	14.22	None
Dwarf Shrub Heath	48.16	4010 North Atlantic wet heaths with *Erica tetralix* 4030 European Dry Heaths
Fen Marsh	32.85	7150 Depressions on peat substrates of the *Rhynchosporion* 7410 Transition mires and quaking bogs
Improved Grassland	1.84	None
Neutral Grassland	3.13	None
Total	**333.96**	

*Habitat data from HBIC.

**The amount of each Annex 1 habitat (if present at all in the ZOI) will vary from near zero toward 100% but without detailed habitat mapping cannot be quantified in detail.

Habitat Management

7.8 As well as the work by Stevens *et al. (*2013) the Government's 'Atmospheric nitrogen theme plan' (GOV.UK, 2015) also makes reference to Smits and Bal (2012). This states:

> '*Recognising that nitrogen deposition levels are likely to remain high at many sites in the coming decades, recovery strategies for sensitive habitats have been developed in the Netherlands to support a Programmatic Approach to Nitrogen (Smits & Bal 2012). These include habitat restoration measures at the regional/landscape level and at the habitat/field level. For example, for some habitats the acidifying impacts of atmospheric nitrogen can be mitigated by restoring the hydrological functioning of a site, which increases the pH and base saturation of acidified habitats. Restoration measures may enable the mitigation of some of the adverse impacts of excess nitrogen while atmospheric nitrogen deposition remains above the CL. This would contribute to help stabilise conditions and alleviate deterioration of the habitat quality, pending further future reductions in deposition through the implementation of local, regional and international measures'*.

7.9 Habitat management measures were discussed at a workshop in 2013, reported in Whitfield & McIntosh (2014) *Nitrogen Deposition and the Nature Directives: Impacts and Responses: Our Shared Experiences*, JNCC Report 521:

> '*Habitat management measures offer a means to reduce the impacts of nitrogen deposition either through removal of nitrogen from the system or through maintaining habitat structure. In some cases, even if the most stringent air pollution control policies*

were to be applied, some ecosystems would not fully recover within a reasonable time period. In these cases, active restoration has to be considered as a necessary management tool to preserve habitats.'

'*This working group aimed to share knowledge and experience of using intensified habitat management to reduce nitrogen impacts and in cases of 'damaged' habitats then use restoration measures.*

It was concluded that each Natura 2000 site is unique in terms of its habitats, species, geographical location, mix of stakeholders and the dynamics of the natural and human interactions that take place in or around that site. Therefore, effective site management requires management of the scientific investigations, the practical techniques to be deployed, well-thought through nature conservation objectives and appropriate management measures, engagement of stakeholders and monitoring to ensure effectiveness.

In the UK, there has been a recent review of the effectiveness of on-site habitat management to reduce atmospheric nitrogen deposition [NB. This is Stevens et al., 2013]. In the Netherlands, a handbook of management and restoration measures for nitrogen effects has been produced [NB this Smits & Bal, 2012].

These studies show that the potential for reducing the impacts of nitrogen deposition varies greatly between habitats and also management practices. Managing for any single issue, such as nitrogen deposition impacts, in isolation may result in unintended and undesirable outcomes and there is a need to consider the conservation objectives of the site and the possible outcomes of a change in management practices.

The working group concluded that whilst in some cases, intensified management measures may partially mitigate impacts and restoration measures, particularly hydrological, have shown some success, alongside this, inputs of nitrogen deposition must be reduced.'

7.10 A review of the effectiveness of on-site habitat management to reduce atmospheric nitrogen deposition impacts on terrestrial habitats (Stevens *et al.,* 2013) provides a detailed breakdown of different management actions in different habitats, including lowland heath, looking at burning, grazing etc. and the benefits and limitations of each.

7.11 A summary of the range of potential management techniques to reduce nitrogen from each of the SAC qualifying habitats is presented in **Table 7.2**.

7.12 It should be noted that a large number of these measures would be inappropriate for many of the New Forest habitats and would be likely to do more harm than good. They are included here, however, for completeness, so that their utility can be considered in the future if necessary.

Table 7.2: Summary of management techniques for reducing nitrogen from SAC qualifying habitats (based on Stevens et al 2013).

SAC Qualifying Feature	Nitrogen Mitigation Measure	Justification	Indicative Cost	Notes
3310 Oligotrophic Waters containing very few minerals of sandy plain (*Littorelletalia uniflorae*)	Not covered in document	-	-	-
3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletalia uniflorae* and/or of the *Isoëto-Nanojuncetea*	Not covered in document	-	-	-
4010 North Atlantic wet heaths with *Erica tetralix*	Turf-Stripping	• Majority of deposited N is retained in the soil, therefore removal is an effective control. • May reduce N productivity for considerable periods of time.	£61.00 - £67.00 per 100m^2	• Unsuitable in areas with archaeological interest. • Costly. • Potential alteration of hydrological regimes. • Likely to result in significant C emissions.
	Rotavating	• Similar benefits to turf stripping, but less costly and no waste generation.	£14.27 - £26.77 per 100m^2	• Does not remove N from the area. • Unsuitable in areas with archaeological interest. • Likely to result in significant C emissions.
	Grazing	• Low intensity management • Reduced maintenance costs.	Would need to be costed for and implemented by a specialist contractor. However, the NF has plenty of grazing animals available so just needs	• Unlikely to remove large accumulations of N in short timescales.

SAC Qualifying Feature	Nitrogen Mitigation Measure	Justification	Indicative Cost	Notes
		• Likely to be most effective when used in combination with other techniques.	organising to graze target areas.	• Likely to result in changes to species composition. • May require supplementary feeding in winter months.
	Cutting	• Modest N removal from otherwise sensitive areas. • Arisings can be used for heathland regeneration elsewhere.	£53.00 per 100m^2	• Unlikely to remove large accumulations of N. • Likely to result in changes to species composition.
	Burning	• Traditional heathland management technique. • Reduces N stored in vegetation significantly.	£100/ha (FC, 2008)	• Not suitable for all heath areas. • Impacts on habitat/ food/ breeding requirements for fauna. • Consider effects of burning on C stocks.
4030 European Dry Heaths	As for 4010			
6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)	Grazing/ Winter Grazing	• Low intensity N management. • Can maintain species diversity whilst	Would need to be costed for and implemented by a specialist contractor. However, the NF has plenty of grazing animals available so just needs	• Unlikely to remove large accumulations of N.

SAC Qualifying Feature	Nitrogen Mitigation Measure	Justification	Indicative Cost	Notes
		providing modest levels of N removal.	organising to graze target areas	• May require supplementary feeding in winter months.
	Cutting	• Modest levels of N removal.	£22.00 per 100m^2	• Unlikely to remove large accumulations of N. • Timing an frequency of mowing may affect seed production and species composition.
	Glycophosphate control of *Brachypodium rupestre*	• *B. rupestre* is a species associated with high levels of N deposition. • Where large stands are present, its removal is likely to reduce accumulation of N.	£5.06 per 100m^2 per treatment in labour £1.22 per ha per treatment in materials.	• Potential for loss of non-target species. • Regrowth in treated areas may differ compositionally from surrounding habitat.
7150 Depressions on peat substrates of the *Rhynchosporion*	Hydrological Management	• There is a general opinion that drier peatlands are more vulnerable to N deposition. • Restoration and maintenance of higher water tables in these habitats may increase critical N loads.	Would need to be costed for and implemented by a specialist contractor.	• Restoration of bogs will increase methane emissions in the short-term. • Emissions of other greenhouse gases are likely in N impacted sites.

SAC Qualifying Feature	Nitrogen Mitigation Measure	Justification	Indicative Cost	Notes
	Burning	• Reduces N stored in vegetation significantly. • Burning in peatlands is of an unproven benefit of N impact amelioration.	£100/ha (FC, 2008).	• Impacts on habitat/ food/ breeding requirements for fauna. • Burning on blanket bogs not encouraged under the Heather and Grass Burning Code (DEFRA, 2007). • Risks loss of C through combustion and promotion of aeolian/ fluvial erosion.
9120 Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrub later	Grazing and Browsing	• It is suggested that deer browsing can help restrict the impacts on N deposition on soil N status.	Would need to be costed for and implemented by a specialist contractor. However, the NF has plenty of grazing animals available so just needs organising to graze target areas.	• Excessive browsing can cause similar, deleterious effects on understorey vegetation as excess N deposition.
	Litter Removal	• Where leaf litter is excessive, its removal can significantly reduce N deposition.	£3.05 per 100m^2	• Removal of other key elements from ecosystem.
	Thinning or Harvesting	• Can provide significant reduction in N accumulated in trees (varies between	£295.00 – £1475.00 per tree (reliant on girth).	• No proven effect on levels of N in soils. • Impacts on habitat/ food/ breeding requirements for fauna.

SAC Qualifying Feature	Nitrogen Mitigation Measure	Justification	Indicative Cost	Notes
		broadleaf and coniferous trees).		• Changes in ground flora composition.
	Burning	• Prescribed fires over intervals of 15 years may reduce N soil pools, where there is not already a significant accumulation.	£100/ha (FC, 2008).	• Not recommended for UK woodland ecosystems. • Impacts on habitat/ food/ breeding requirements for fauna. • Changes in ground flora composition.
9130 *Asperulo- Fagetum* beech forests	As for 9120.			
9190 Old acidophilous oak woods with *Quercus robur* on sandy plains	As for 9120.			
91D0 Bog woodland	A combination of techniques from 7150 and 9120 is likely to be effective.			
91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsor*	As for 9120.			
7410 Transition mires and quaking bogs	Grazing	• Low intensity N management.	Would need to be costed for and implemented by a specialist contractor. However, the NF has plenty of grazing animals available so just needs organising to graze target areas.	• Unlikely that grazing with provide significant benefits in mitigating N deposition impacts in fens, marshes or swamps.
	Cutting	• Evidence suggests that long-term and regular mowing and hay removal in these	£22.00 per 100m^2	• Changes in species composition. • Timing and frequency of cutting may

SAC Qualifying Feature	Nitrogen Mitigation Measure	Justification	Indicative Cost	Notes
		habitats can remediate significant amounts of N deposition. • Long-term management by mowing may also help these habitats become insensitive to additional N inputs.		adversely affect seed production/ species composition.
	Hydrological Management	• Reduction in hydrological inputs to these habitats may help reduce baseline N inflow and make them more resilient to atmospheric N inputs.	Would need to be costed for and implemented by a specialist contractor.	• Managing water levels may alter nutrient inputs to the site. • Changes in species composition.
	Topsoil Removal	• Highly effective in removing large accumulations of N in soil.	£8.20 per m^3	• High levels of habitat disturbance. • Only appropriate in extreme cases of nutrient enrichment (where wetland has been converted to farmland, for example).
7230 Alkaline Fens	As for 7140			

Mitigation Measures in the Context of Existing Habitat Management

7.13 The New Forest habitats are already managed in accordance with management plans and so any mitigation measures would need to take account of the existing management arrangements. Moreover, the measures proposed can be readily tied in to existing arrangements rather than having to be newly devised which would save costs.

7.14 A brief overview of the main management arrangements is included here to provide context as to how the management being suggested can be effectively delivered as part of New Forest management plans, if it was required.

The New Forest Special Area of Conservation (SAC) Management Plan

7.15 The New Forest Special Area of Conservation (SAC) Management Plan (2001) outlines the principle aims of management of the New Forest vegetation communities and provides a set of generic prescriptions and rationales detailing the form of management required.

The New Forest Heathland Plan

7.16 The New Forest Crown Lands Management Plan: Heathland Plan (Forestry Commission, 2008) forms a relevant part of the SAC Plan.

7.17 The SAC Plan states that New Forest heathland is extensive, including 7,600 ha of dry heath, 2,110 ha of wet heath and 2,021 ha of valley mire communities.

7.18 The Forestry Commission Heathland Plan states that:

> "*grazing by horses and cattle is an integral part of New Forest heathland management. The heathland, mires and grasslands have been grazed by communing stock for centuries, which has led to a unique landscape and habitats so characteristic of the Open Forest. Indeed many of the traditional heathland management techniques which have been practised through the ages are still applied today*".

7.19 Apart from grazing, it identifies 'cutting' and 'burning' as the two main heathland management activities, other than bracken control. The wet heath communities are strongly influenced by burning and grazing. Burning and grazing is also essential to support dry heath communities.

7.20 Issue 6 within the Heathland Plan is Delivery of the Cut and Burn Programme:

> "*Controlled Burning is an effective management technique for vegetation control which, provides a number of benefits for habitat management and grazing. The FC will continue to give priority to the achievement of an agreed programme of cutting and controlled burning to promote fresh growth of gorse, heather and Molinia and to control the re-growth of Scots Pine. Controlled burning is recognised as being a primary management tool for the maintenance of wet and humid heaths and valley mores within the New Forest SAC. On average 400 ha are burnt each year*'.

> '*Cutting is used both in conjunction with burning and as an alternative method of vegetation control. Cutting is carried out using mowing/swiping with a tractor mounted machine or hand cutting with chainsaws, brush cutters, bow saws or loppers. Cutting is*

primarily used for controlling pine and birch succession, gorse, willow and general scrub management. On average 36 ha are cut each year'.

'*Heather baling has taken place on up to 50 ha of heath to supply heather bales for large scale restoration projects. Heather bales can be produced by request as part of the winter management of the Open Forest heathlands, particularly for dry heathland management. A maximum of 12,000-14,000 bales can be produced in a winter but used within a year of cutting to avoid degradation*."

The New Forest Inclosures Plan

7.21 The New Forest Crown Lands Management Plan: Inclosures Plan (Forestry Commission, 2008) also forms a relevant part of the SAC Plan:

> "*The Inclosures were generally established on former heathland or ancient woodland sites and remnants of these former habitats still survive within the modern day Inclosures. Where recognisable, these remnant heathland and woodland habitats are often of international importance representing important examples of Annex 1 habitats. Of particular significance are the 400 ha of pasture, riverine and bog woodland communities that were incorporated into the 18th and 19th century Statutory Inclosures*."

7.22 The Inclosures Plan makes reference to the Forest Design Plan, and its objectives includes setting out the means by which the Inclosures will be managed to transfer habitats back to those of nature conservation importance over commercial interests partly by timber harvesting and replanting with broadleaves, remove fencing where undesirable whilst protecting certain biodiversity from grazing by maintaining fencing, and monitoring to inform future management. This includes monitoring plant health and reacting to outbreaks of pests and diseases.

Summary

7.23 The New Forest is already the subject of detailed management for nature conservation under established management plans which are informed by monitoring.

7.24 There is high confidence that should monitoring of the effects of air quality on habitats require remedial action, that the range of management measures that can be applied to address any measured problems can be instigated alongside existing measures through adapting the location, extent, duration or frequency, intensity of measures already practised (grazing, burning, cutting, baling).

7.25 The only potential exception to this is in respect of potential effects on sensitive Epiphytic lichen assemblages associated with Annex 1 woodland habitats, arising from possible increases in ammonia levels in future. Although the provision of shelterbelts would provide protection for lichens, in some places lichen-rich old-growth metasites are located immediately adjacent to the road edge and no such opportunity for shelterbelt provision exists in the intervening space. Information available to date suggests that existing levels of pollution are not causing a negative effect, and that penetration of reactive Nitrogen into woodland areas is not presently significant. Consequently, the monitoring methods outlined above in **Section 6** may need to be relied upon to detect the early warning signs that ammonia levels may be beginning to have an effect, so that other (non-ecological) measures may be brought to bear (i.e. traffic reduction measures such as those outlined in paragraphs 5.12 to 5.14 above).

8. COSTINGS

Introduction

8.1 It is proposed that the costs of future monitoring and management measures should be funded through developer contributions collected by the respective LPA through legal agreements (Section 106 Agreements or Unilateral Undertaking).

8.2 The costs provided at this stage are rough estimates only and are based on various assumptions detailed in the sections above. They do not consider site-specific issues that may increase the time needed to complete the relevant tasks, such as obtaining access, or producing formal reports of results for purposes other than internal use. It is suggested that a contingency is allowed for such unforeseeable costs up to around 10% of the costs listed in the table below.

Measures to Address Immediate Information Deficits

8.3 Based on the presumed effort outlined above in **Section 6**, we anticipate the 'one off' costs to address information deficits to be in the region of the figures shown in **Table 8.1** below.

Table 8.1: Summary of Initial (one-off) Costs.

Work Item	Anticipated Cost Estimate	Notes
National Vegetation Classification (NVC) Mapping of Proposed Monitoring Areas	£10,237.5 - £14,175	Based on upper estimate of 21 day's work at a senior practitioner level
Baseline Lichen Survey of Flat Habitat Monitoring Areas 2 and 3	No additional cost	Assumes NVC surveyor can combine surveys

Monitoring

8.4 The cost of future habitat monitoring based on the methods described above in **Section 6** are provided as a summary in **Table 8.2**.

Table 8.2: Summary of habitat monitoring costs.

Monitoring Item	Sampling method (per site)	Frequency	Indicative Unit ('per survey') Cost	Indicative total annual cost to 2036
Monitor 3 locations for 'short' habitats shown on **Map 6.1**	Transect-based survey method as described	Estimate 8 day's work every 3 years	£3,900 - £5,100 (Indicative additional lab costs = £2,250)	£23,400 - £30,600 (Indicative additional lab costs = £13,500)
Monitor 4 locations for 'tall' habitats shown on **Map 6.2**	APIS method using epiphytic lichen monitoring of tree twig and trunks	Estimate 8 day's work Every 3 years	£3,900 - £5,100	£23,400 - £30,600

Habitat Management

8.5 Indicative costs for habitat management on a ‘per unit area’ basis are listed previously in **Section 7**. At this stage, the extent to which these may be required is unknown and will be determined by future monitoring.

Caveat

8.6 The monitoring methods outlined in **Section 6** and costed above are intended to cover the specific need to put in place monitoring mechanisms that to detect the effects of traffic related air pollution at the earliest possible stage and trigger the need for further measures (potentially including mitigation).

8.7 In such circumstances, further work might be necessary to investigate the full extent of any impacts to habitats so that the full scope of mitigation measures required could be implemented and funded. The costs outlined above do not account for such reactive investigative work, as the frequency and scope required will be determined solely by requirements that cannot be foreseen. It will be necessary to regularly review the adequacy of the abovementioned funding streams with this in mind, to ensure that they remain adequate.

9. SUMMARY AND CONCLUSIONS

9.1 This report comprises the results of a detailed literature review and the results of a fieldwork exercise designed to investigate the potential for modelled predicted of traffic-related nitrogen air pollution (including NOx, nitrogen deposition and ammonia) to affect the internationally important Annex 1 habitats for which the New Forest SAC was designated, and by extension those of the other International designations.

9.2 The results of the fieldwork and desktop review, taken together, have not yielded any evidence to indicate that New Forest habitats are currently experiencing negative effects from traffic related air pollution.

9.3 The results of our work and the analysis that we have carried out did not reveal anything to suggest that present levels of traffic-related air pollution are the underlying cause for any observable patterns or observations in vegetation that could be linked to an adverse effect on the integrity of the SAC habitats.

9.4 Notwithstanding the above, and despite historically higher levels of air pollution (particularly SO_2 and acid deposition) experienced across the New Forest, Air Quality Modelling work (AQC, 2018) indicates that there will be increases in traffic-related nitrogen pollution on roads across the New Forest, some of which will be in exceedance of the relevant CLs, and toward which the Local Plans will contribute more than 1% of the CL (i.e. the anticipated concentrations of the modelled pollutants are predicted to be at levels at which the potential for harm cannot be ruled out on the basis of the air qualify modelling alone, and the Local Plans are in places predicted to make a material contribution to those levels).

9.5 Additionally, future improvements in vehicle technology such as Selective Catalytic Reduction (SCR) technology may have the effect of reducing overall levels of NOx at the expense of increasing levels of ammonia (NH_3). Ammonia is a gaseous form of reactive nitrogen that can, in sufficient quantities, affect changes in vegetation composition and negatively affect particularly sensitive species such as epiphytic lichens, for which the New Forest is Internationally important.

9.6 Notwithstanding the particular sensitivity of epiphytic lichens, it is unlikely that the predicted increases in ammonia will have significant implications for vascular plants and vegetation communities, as the CL used in the assessment work has been set very low (1 $\mu g/m^3$) due to the presence of the aforementioned sensitive lichen species (the CL for vascular plants is 300% higher at 3 $\mu g/m^3$, and consequently is it unlikely that ammonia concentrations could reach levels high enough to affect vascular plants).

9.7 As a result of the above observations, air pollution modelling and habitat data have been used to identify areas that may be at higher risk from these and other predicted changes to future levels of aerial pollutants, and a monitoring strategy has been developed.

9.8 The monitoring strategy is designed to provide the earliest possible indication that the forms of nitrogen pollution discussed (including ammonia concentrations) are beginning to affect vegetation, so that, if necessary, measures can be taken to mitigate the impact and prevent an adverse effect on the integrity of the SAC habitats from occurring.

9.9 A literature review has also been undertaken to identify potentially suitable mitigation measures, so that these can be considered at the point at which the requirement for them becomes apparent. In general these prospective measures are readily implemented, and in many cases are already taking place as part of the active and ancient management of the New Forest.

9.10 The potential exception to this is in relation to epiphytic lichens associated with Annex 1 woodland habitats, as in places lichen-rich old-growth metasites occur immediately adjacent to road corridors. Although the provision of shelterbelts are likely to be effective means to protect epiphytic lichens from pollutants, in such places the space does not exist to accommodate these features. Evidence presently available suggests that current levels of traffic-related pollution are not currently affecting epiphytic lichens within the forest, and that penetration of pollutants into woodland is not great. Although the prospects for the provision of shelterbelts could be examined further, in these specific instances, the recommended monitoring strategy will be key to providing an early warning that epiphytic lichens are beginning to be affected, so that other non-ecological measures can be taken relating to traffic reduction etc.

9.11 Estimated costs for all recommended monitoring and mitigation measures have been provided, although these will need to be kept subject to review.

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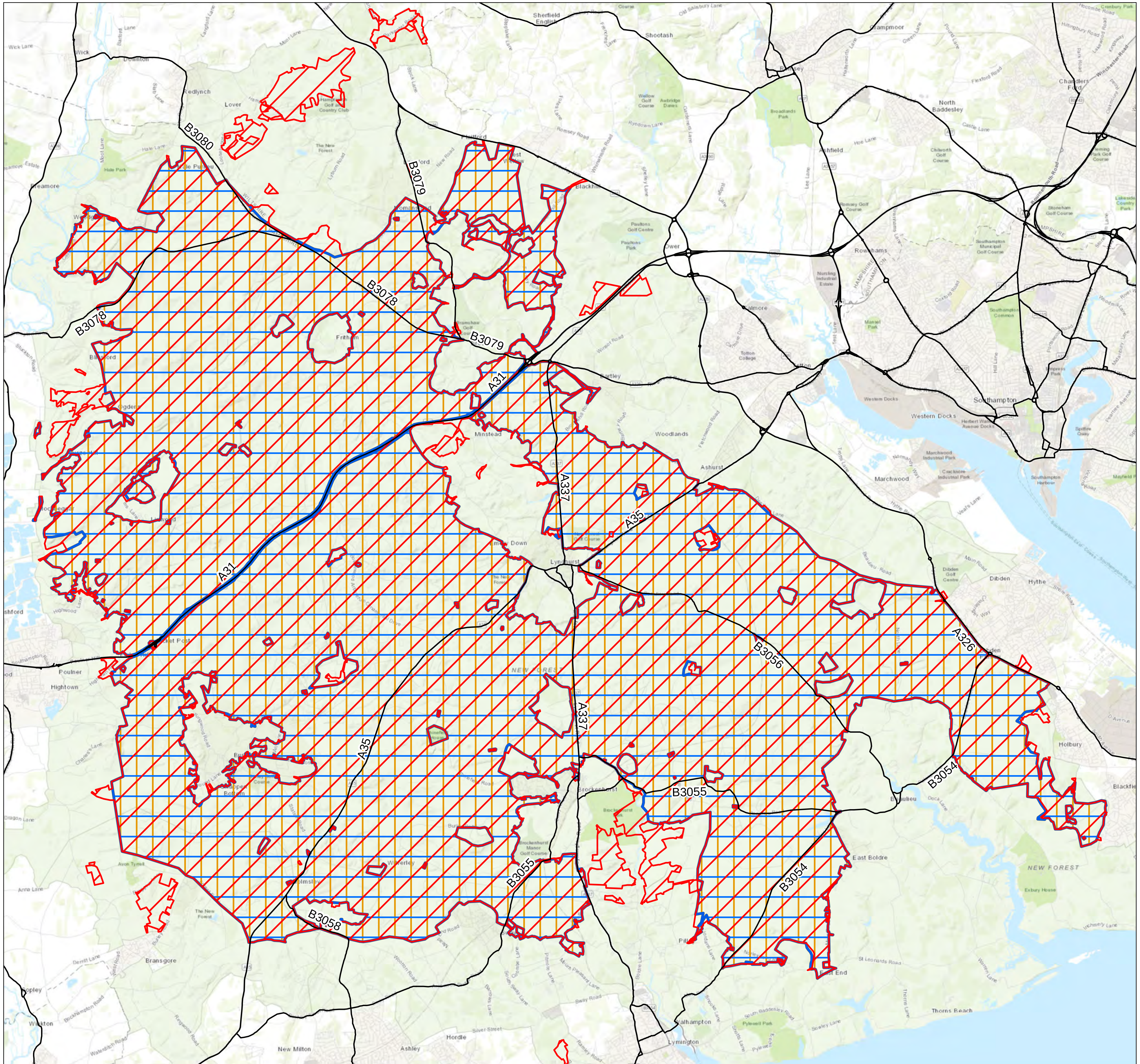

MAP 1.1 New Forest Designations

KEY

- Road network
- New Forest Special Protection Area (SPA)
- The New Forest Special Area of Conservation (SAC)
- New Forest Ramsar

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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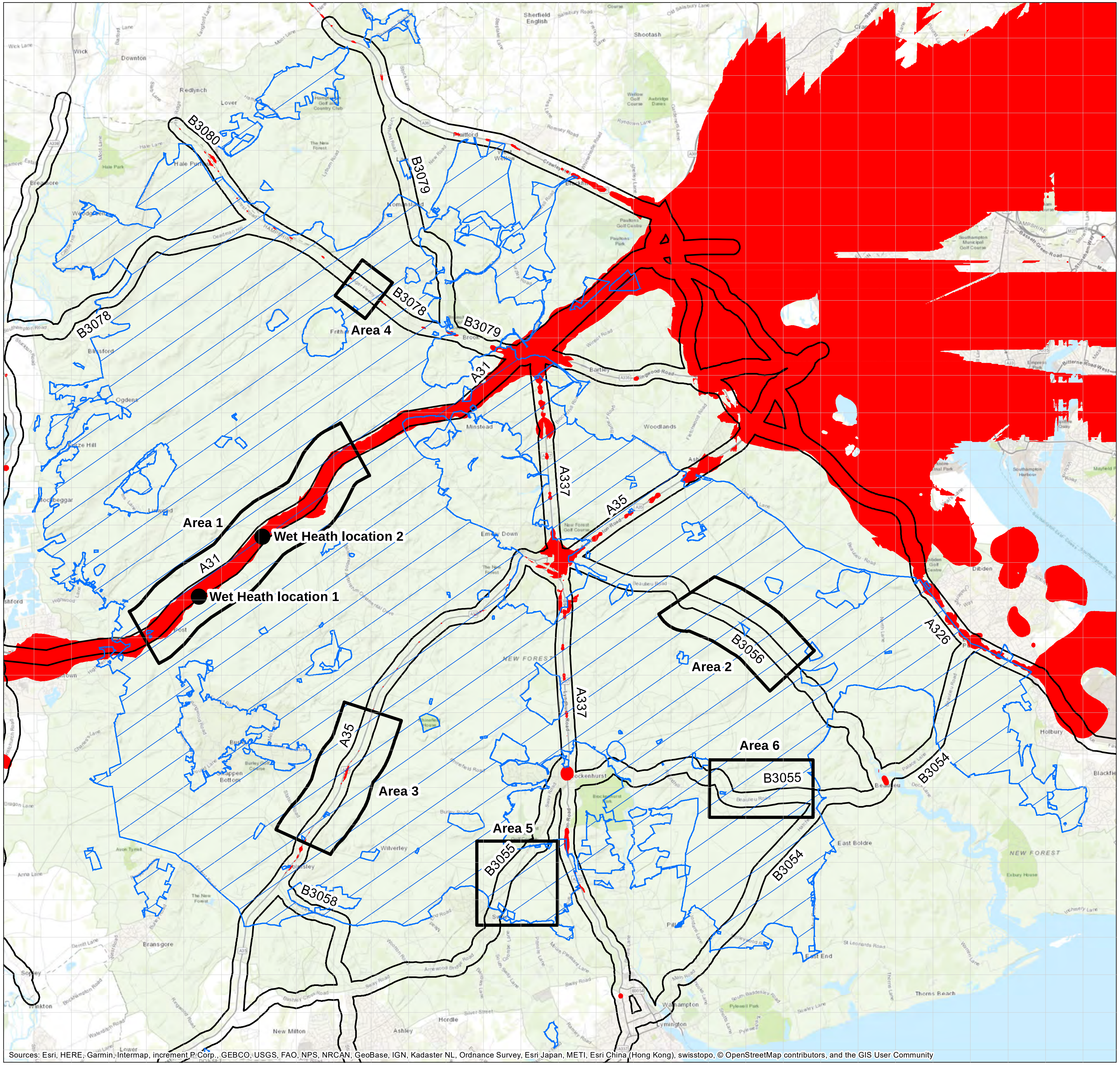

MAP 3.1 Broad Survey Locations with 2015 Annual Mean NOx 30µg/m3 Exceedance (Sensitivity Test Scenario)

KEY

- New Forest Designated Sites
- 200m buffer of roads
- Sampling location
- Wet Heath sampling location
- Annual mean NOx - 30 ug/m^3 exceedence

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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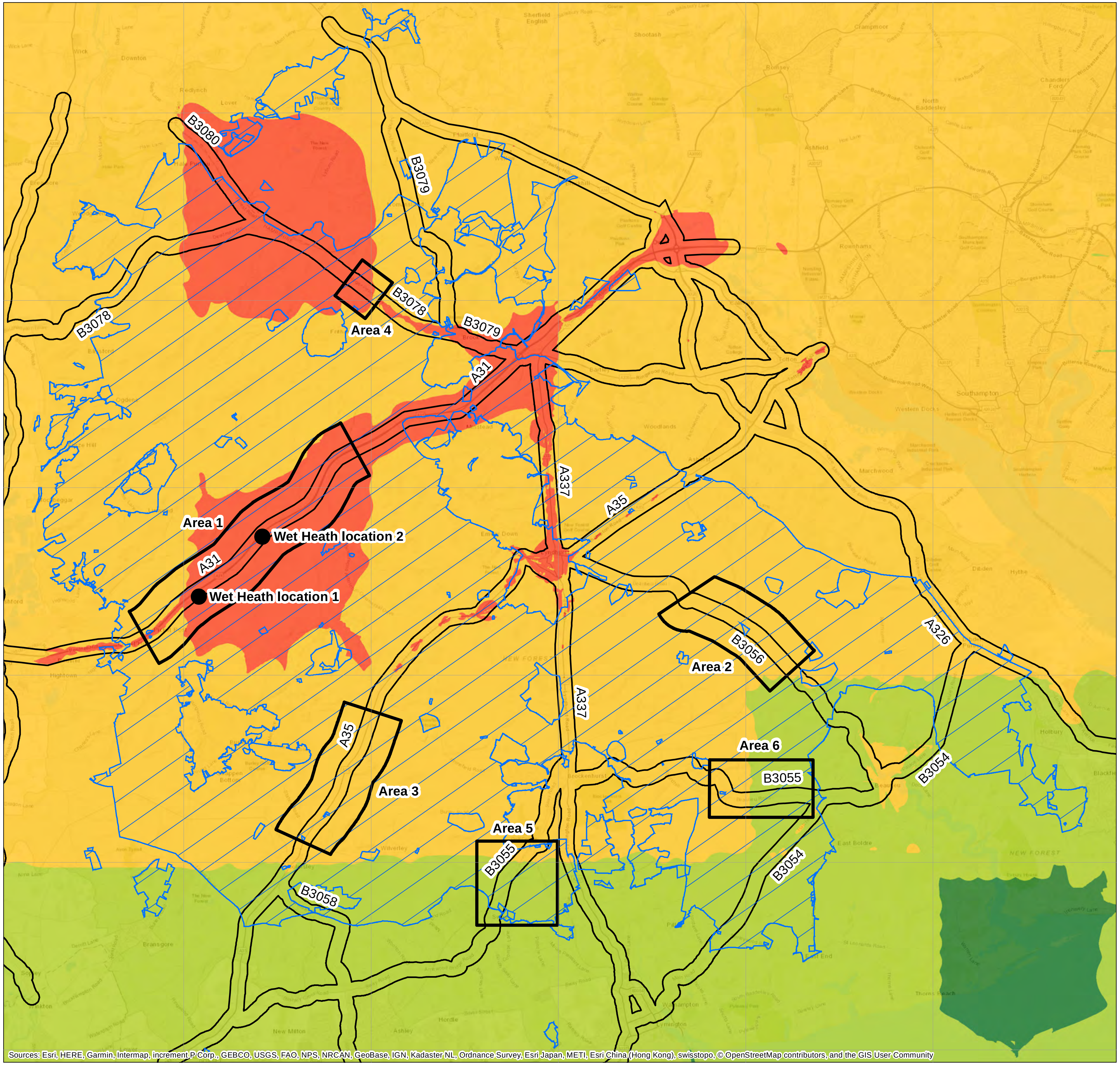

MAP 3.2 Broad Survey Locations with 2015 Nitrogen Deposition for Grassland Habitats (Sensitivity Test Scenario)

KEY

New Forest Designated Sites

200m buffer of roads

Sampling location

Wet Heath sampling location

Nitrogen Deposition - Grassland

CL

8

10

15

20

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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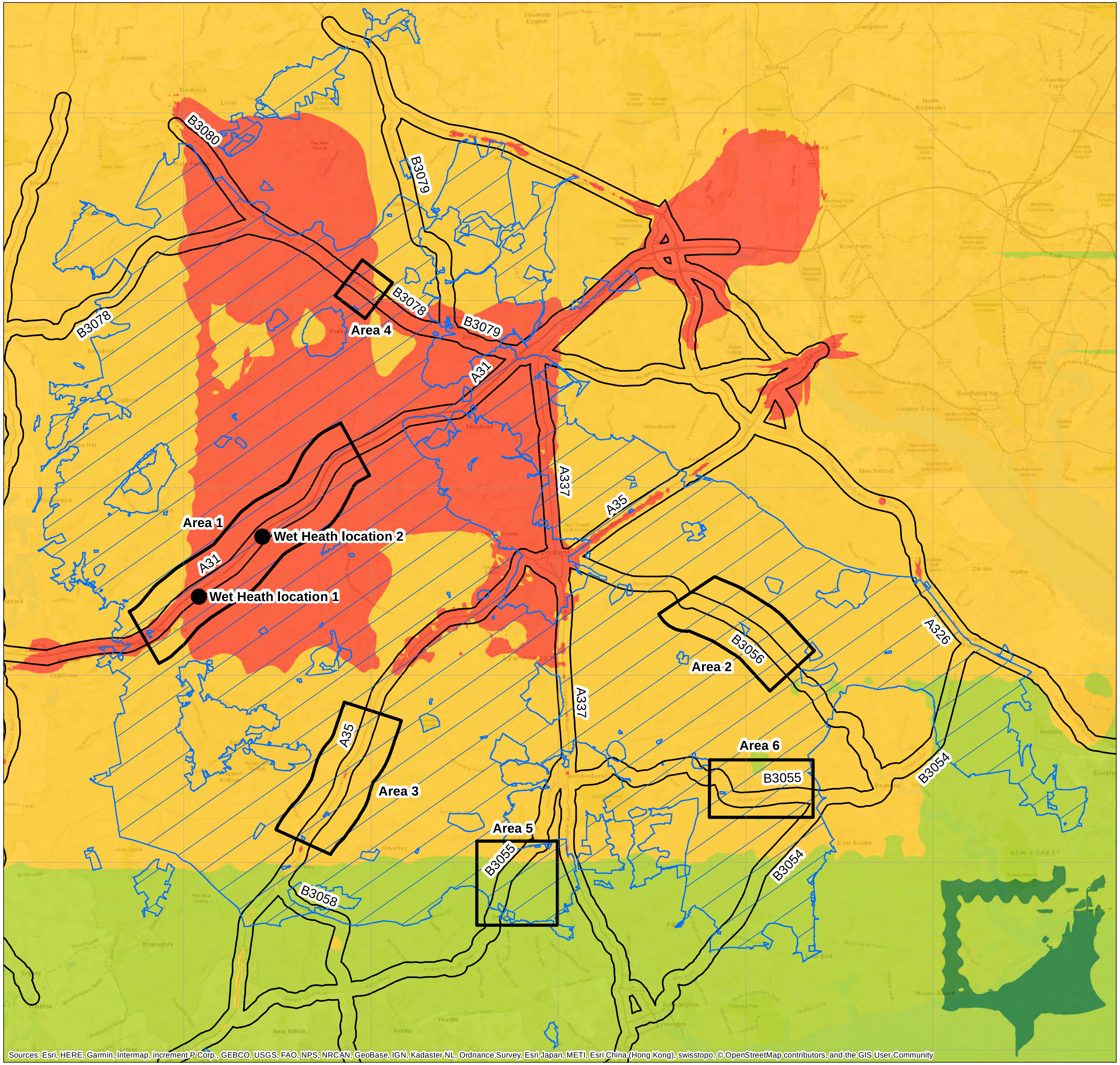

MAP 3.3 Broad Survey Locations with 2015 Nitrogen Deposition for Woodland Habitats (Sensitivity Test Scenario)

KEY

- New Forest Designated Sites
- 200m buffer of roads
- Sampling location
- Wet Heath sampling location

Nitrogen Deposition - Woodland

CL

- 8
- 10
- 15
- 20

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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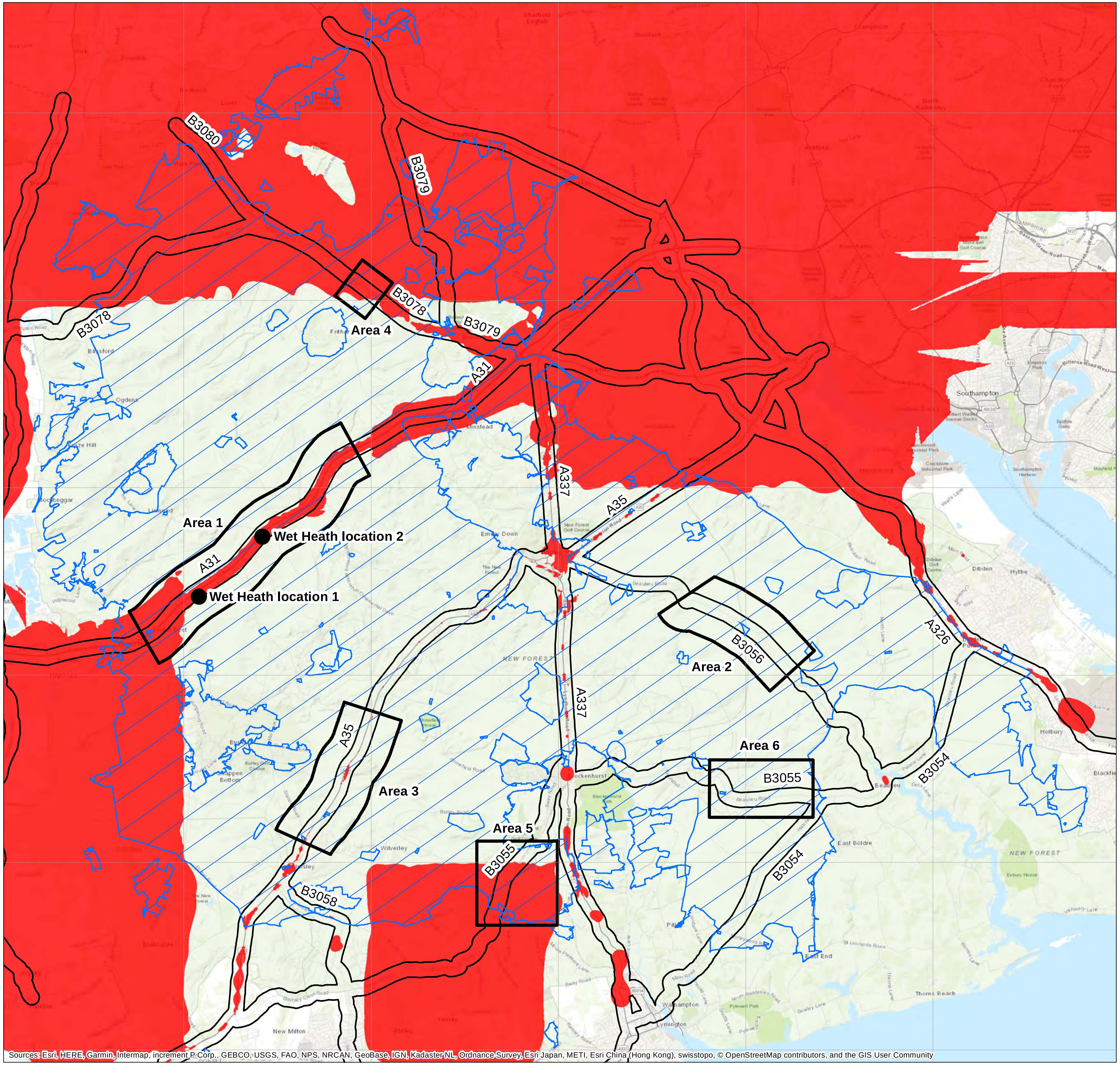
MAP 3.4 Broad Survey Locations with 2015 Ammonia 1 ug/m3 [3] Exceedence (Sensitivity Test Scenario)



KEY

- New Forest Designated Sites
- 200m buffer of roads
- Sampling location
- Wet Heath sampling location
- Ammonia 1 ug/m3 [3] exceedence

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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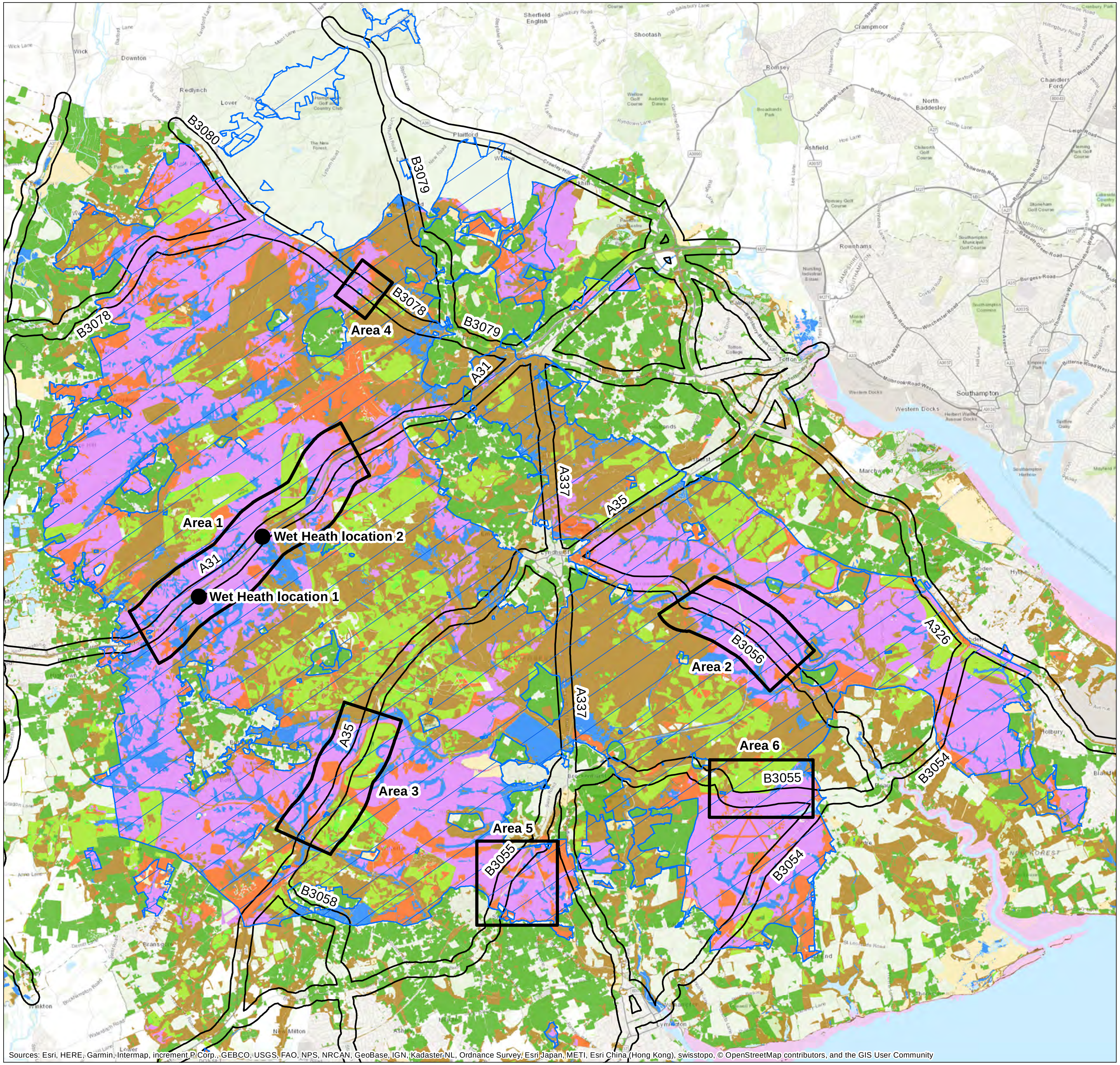

MAP 3.5 Broad Survey Locations with Habitat Types

KEY

- New Forest Designated Sites
- 200m buffer of roads
- Sampling location
- Wet Heath sampling location
- Acid Grassland
- Bracken
- Broadleaved
- Calc Grassland
- Con Woodland
- Dwarf Shrub Heath
- Fen Marsh
- Improved Grass
- Litt Sed
- Neutral Grassland
- Super Sediment

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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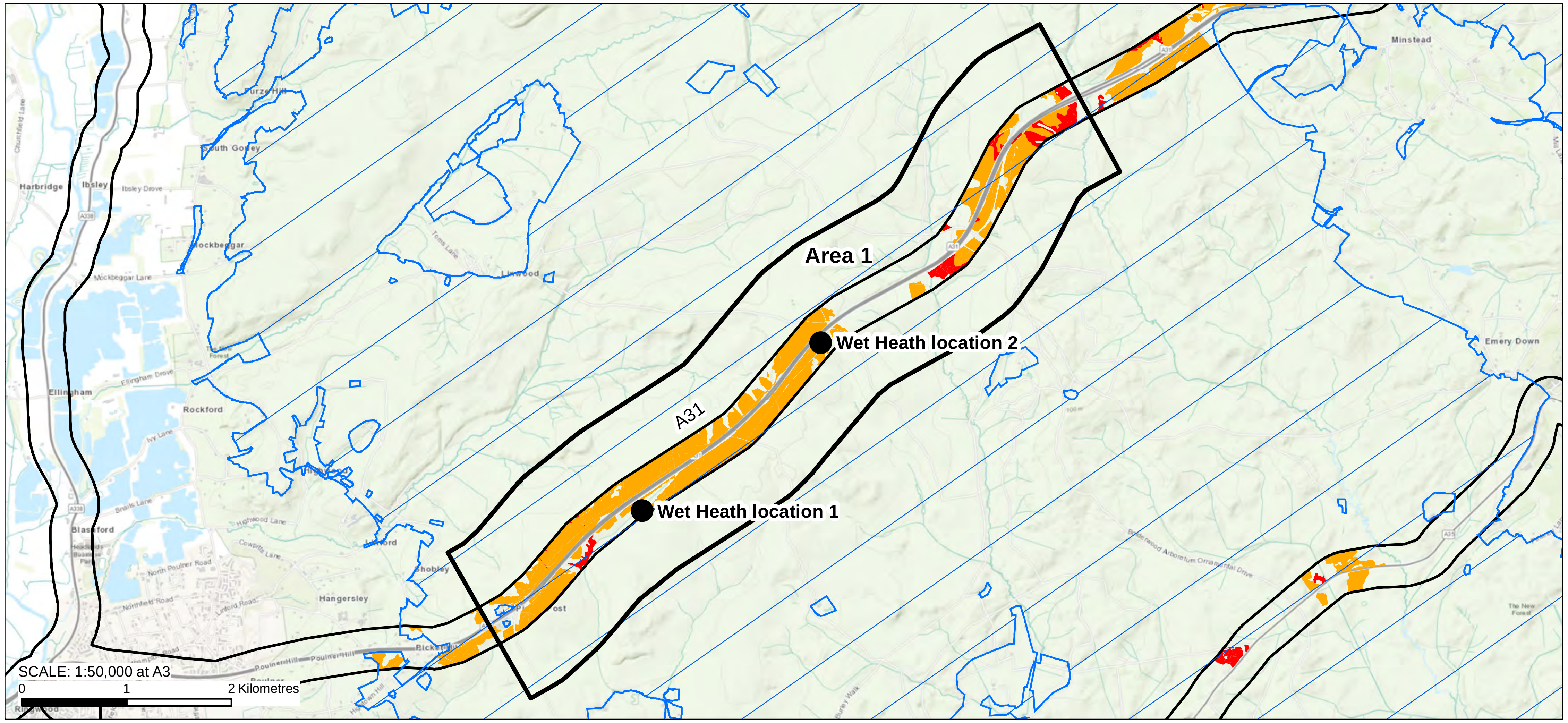

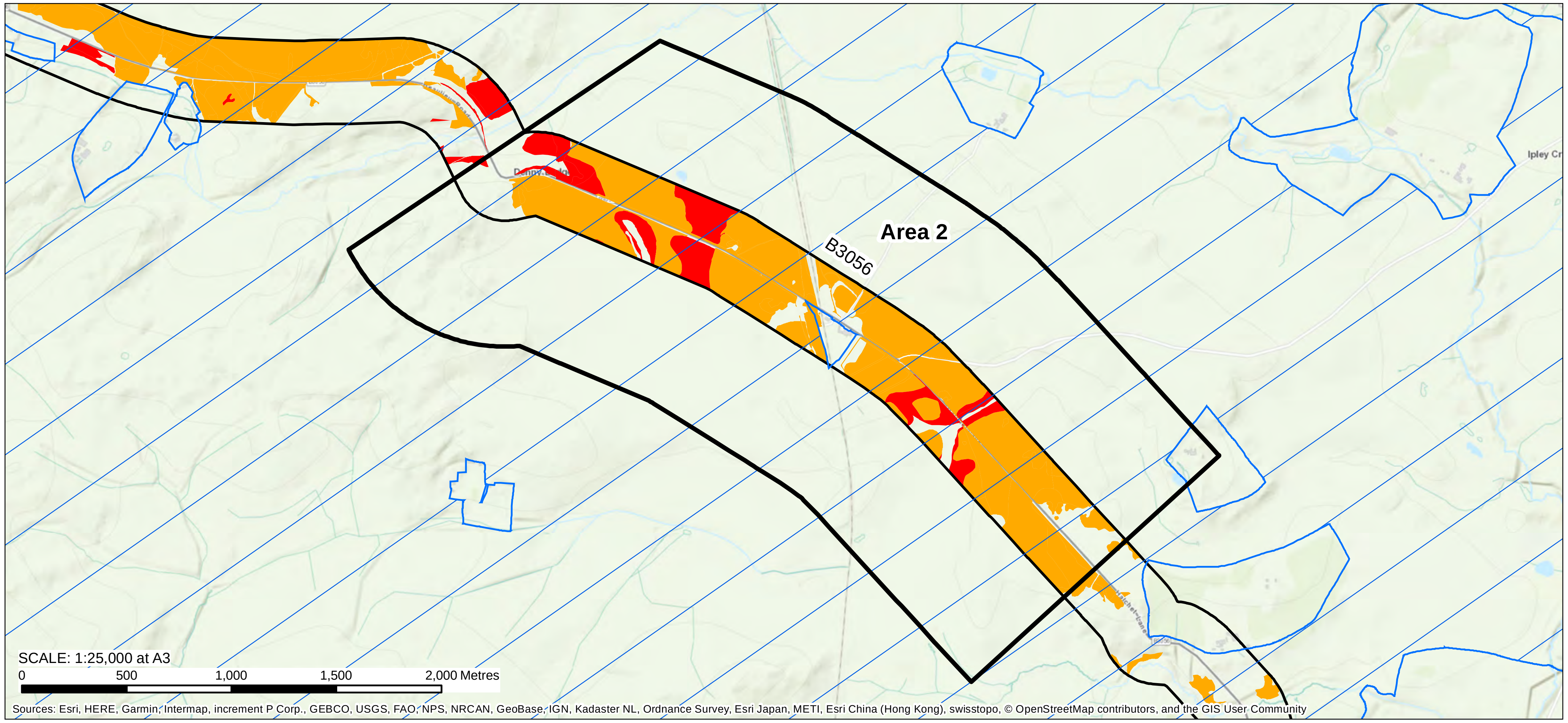

MAP 3.6 Broad Survey Location 1 & 2

KEY

- New Forest Designated Sites
- 200m buffer of roads
- Sampling location
- Wet Heath sampling location
- HE1 : European dry heaths
- HE2 : Wet heaths

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MAP 4.1 Actual Transect Locations

KEY

• Transect samples

SCALE: 1:6,500 at A3

0 50 100 150 200 Metres

N

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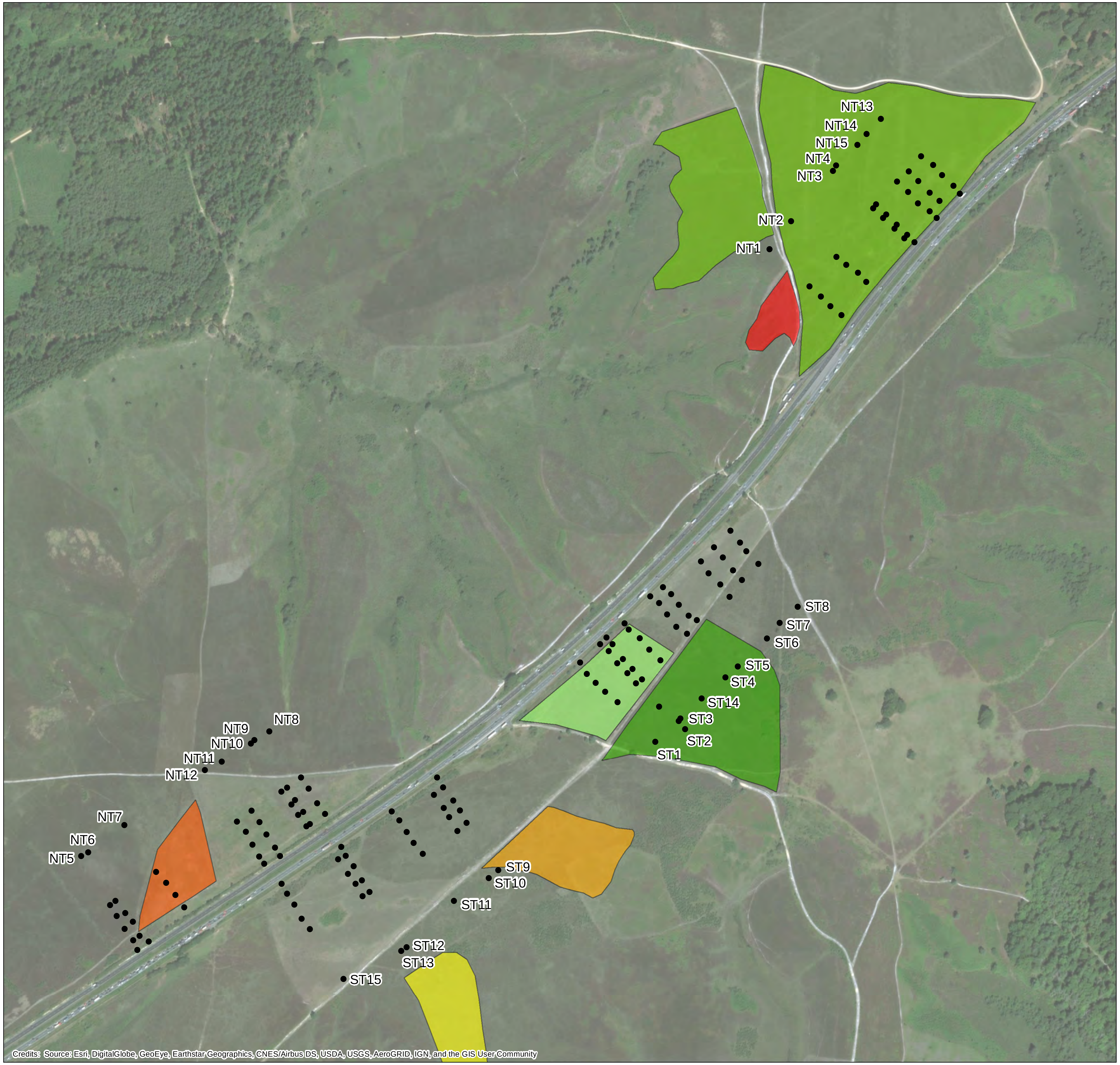
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



MAP 4.2 Transect Sample Locations and Managed Burn Areas

KEY

• Transect samples

Year of burn

- 98
- 05
- 07
- 08
- 10
- 14
- 15

SCALE: 1:6,500 at A3

0 50 100 150 200 Metres

N

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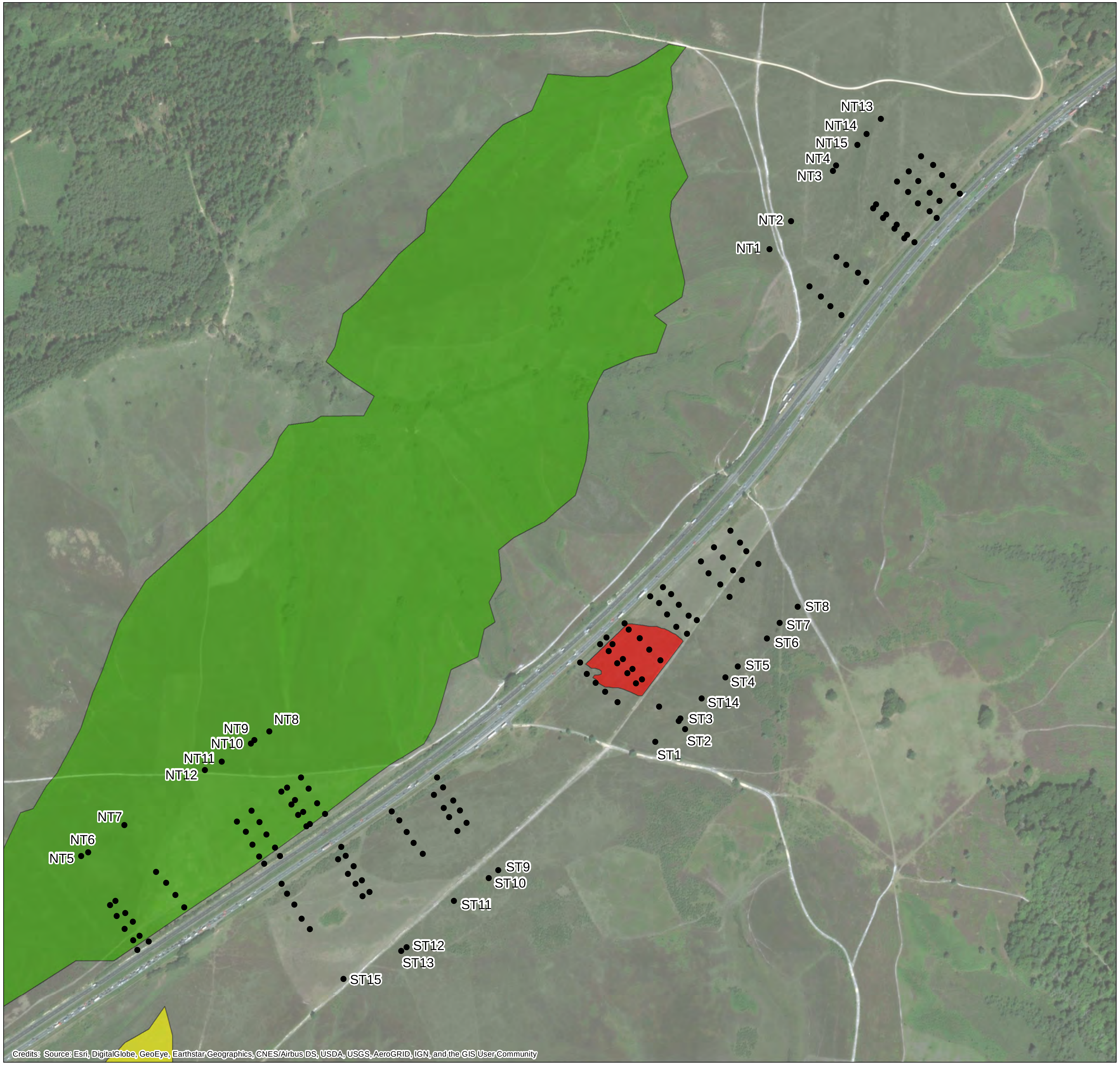
MAP 4.3 Transect Sample Locations and Wildfire Areas



KEY

- Transect samples

Year of wildfire

- 89
- 95
- 06

SCALE: 1:6,500 at A3

0 50 100 150 200 Metres

N

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MAP 4.4 Transect Sample Locations and Cut Areas

KEY

- Transect samples

Year of cut

- 09
- 10
- 15

SCALE: 1:6,500 at A3

0 50 100 150 200 Metres

N

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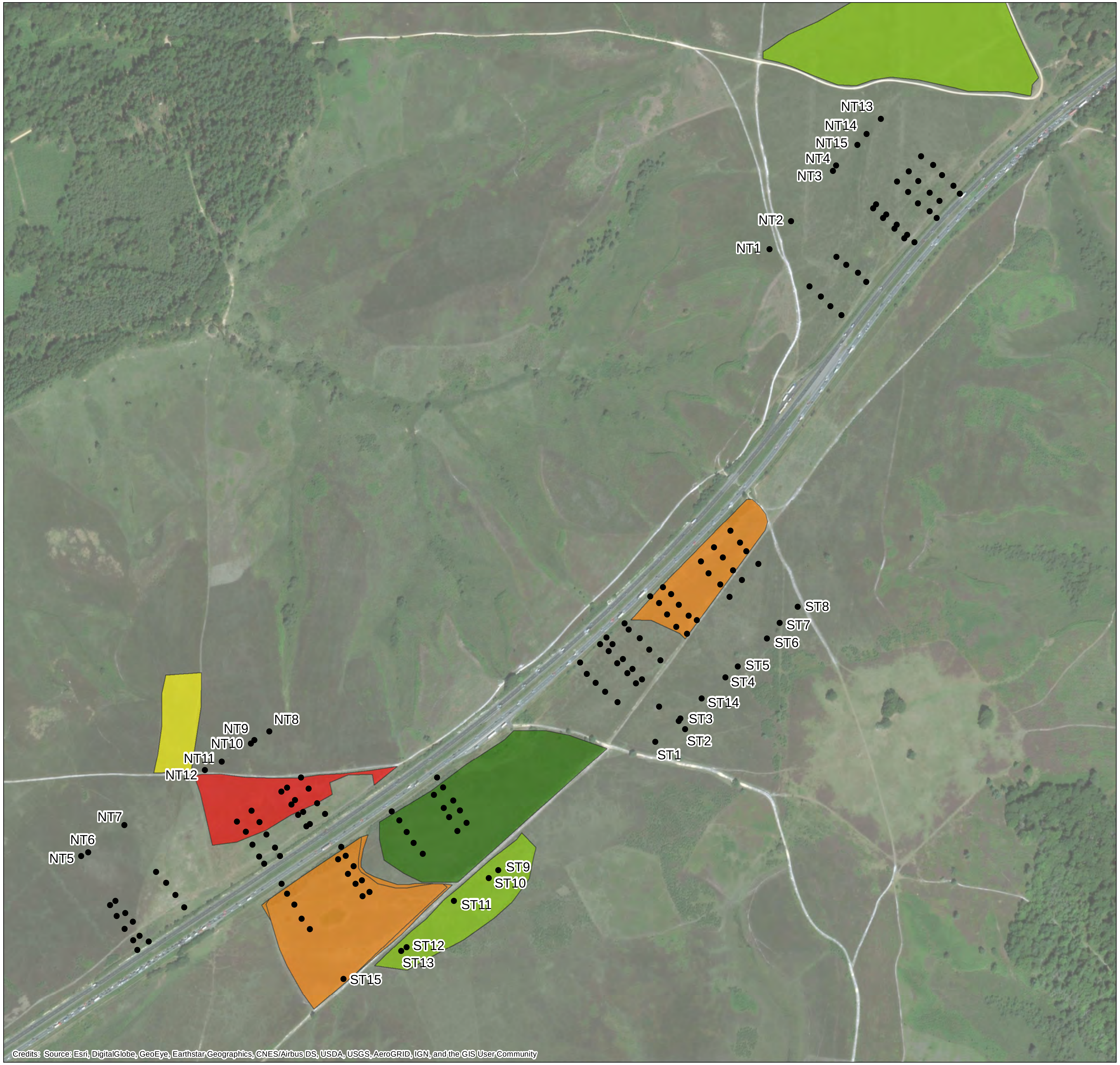

MAP 4.5 Transect Sample Locations and Bale Areas

KEY

- Transect samples

Year of bale

- 01
- 06
- 14
- 15
- 16

SCALE: 1:6,500 at A3

0 50 100 150 200 Metres

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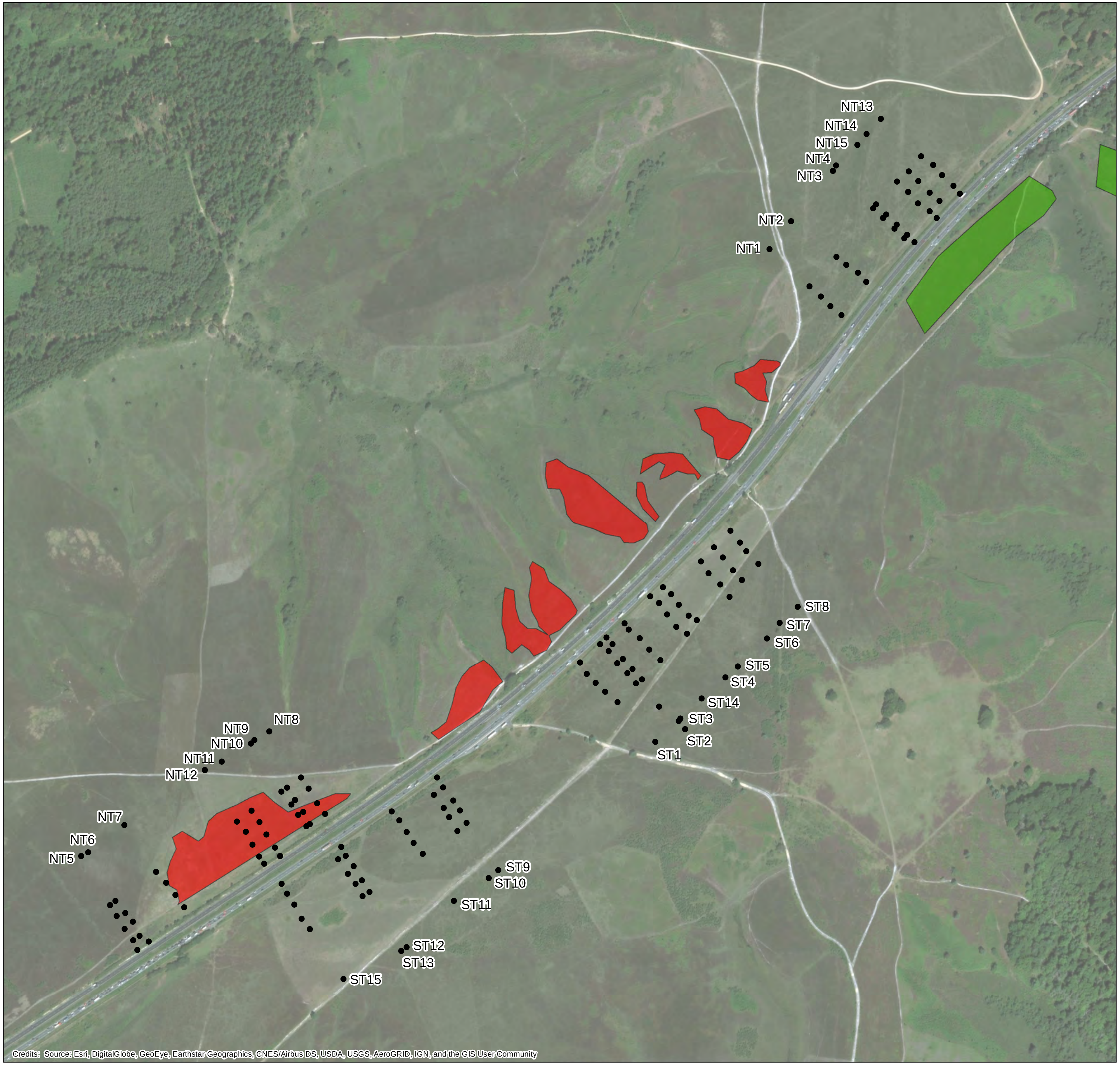

MAP 4.6 Transect Sample Locations and Bracken Treatment

KEY

Transect samples

Year of bracken spray

08

15

SCALE: 1:6,500 at A3

0 50 100 150 200 Metres

N

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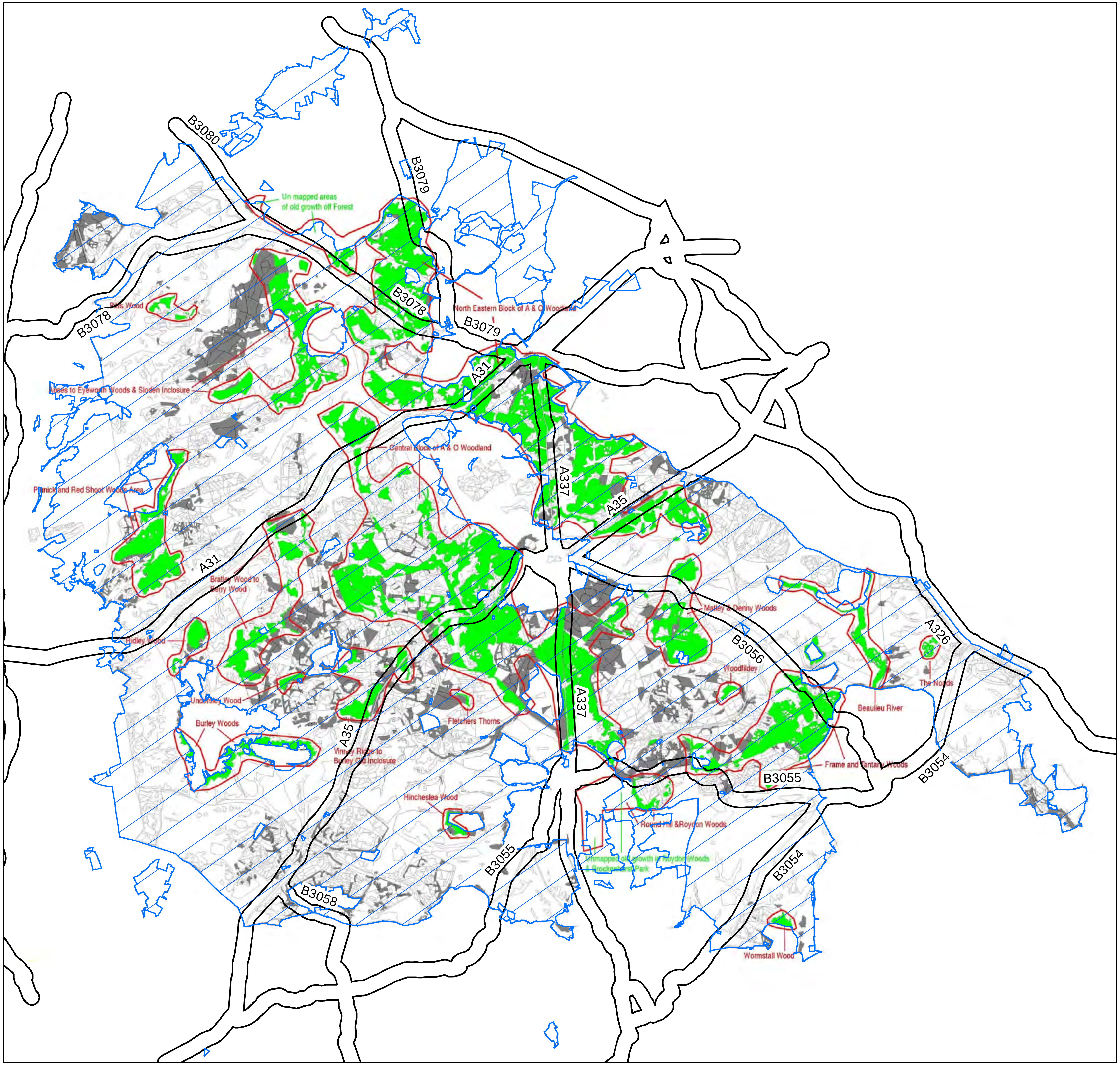
MAP 4.7 Strategic Road Network in Relation to Lichen-Rich Old Growth Meta Sites



KEY

- New Forest Designated Sites
- 200m buffer of roads
- Existing old growth woodland
- 19th Century broadleaved stands
- Lichen rich old growth meta-sites

The locations of the woodland areas shown on this map have been provided by Neil Sanderson from his personal data. The map is based on Sanderson (2007) and includes subsequent amendments.

Sanderson, N. A. (2007) New Forest Inclosure Habitats, Habitat Fragmentation & Landscape History. Botley: Hampshire & Isle of Wight Wildlife Trust.

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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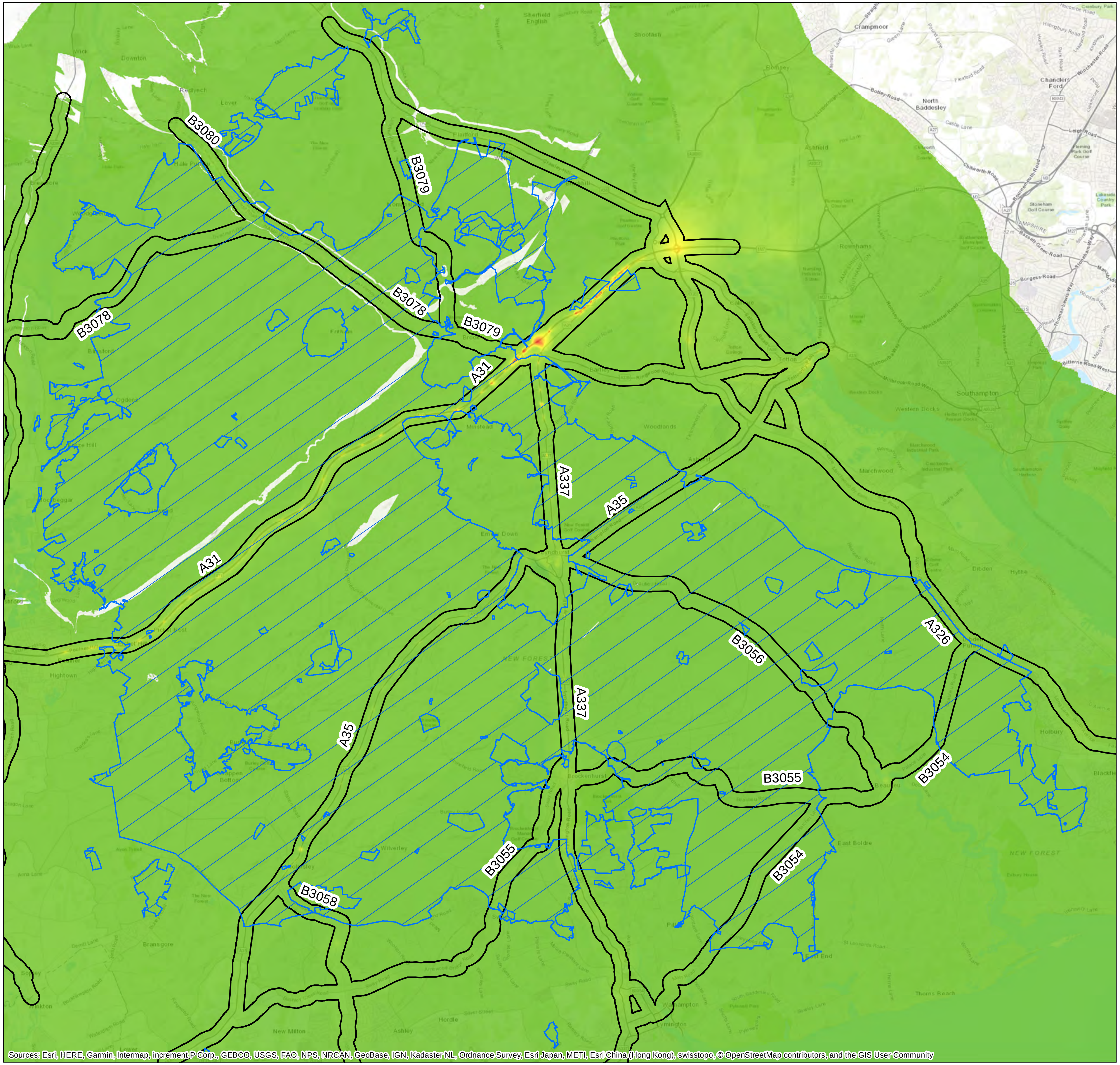
MAP 5.1 2036 Percentage Changes in Ammonia Concentrations In-Combination



KEY

New Forest Designated Sites

200m buffer of roads

2036 Percentage Changes in Ammonia Concentrations In-Combination - Max

-5.300000

69.462303

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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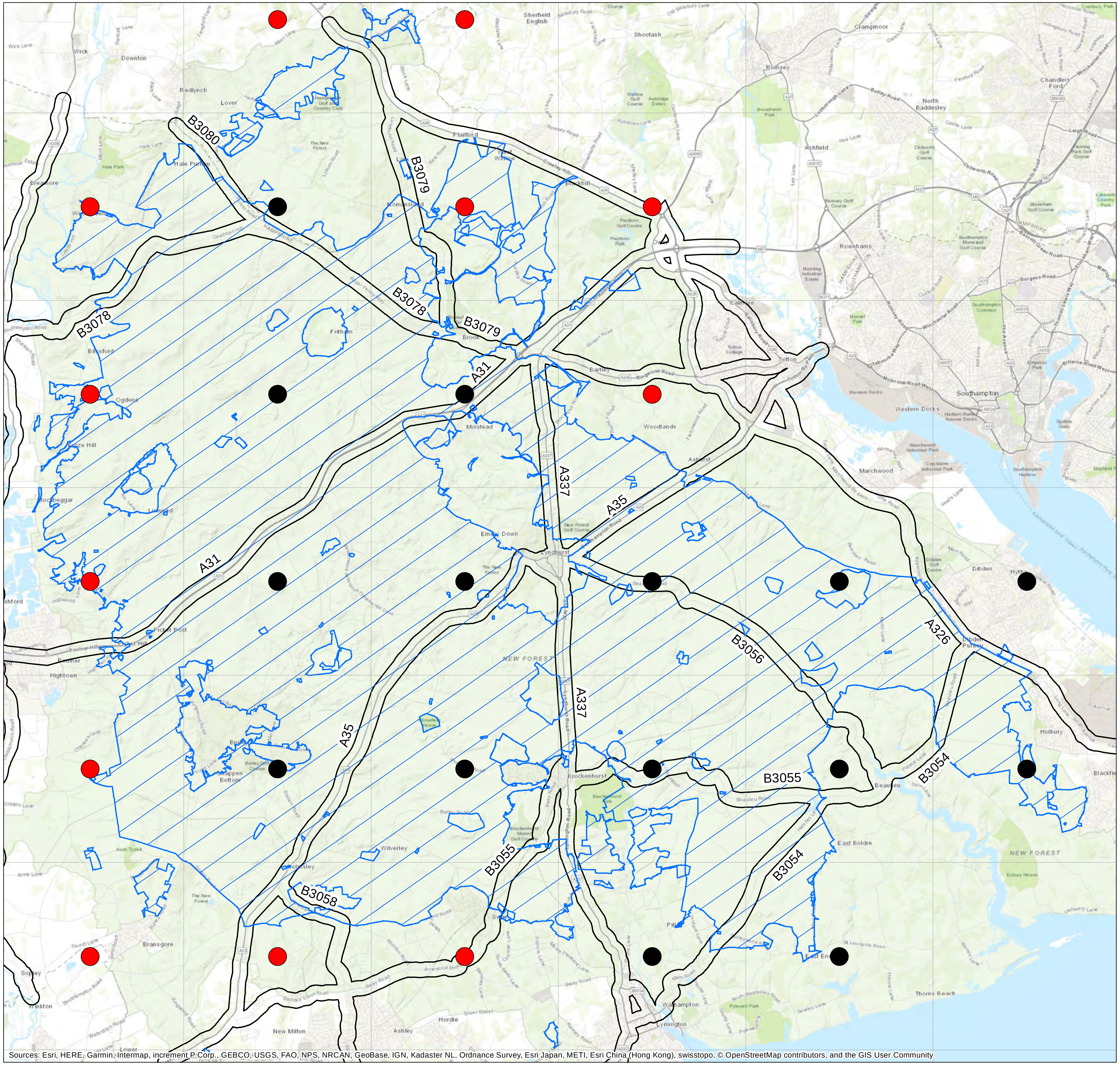

MAP 5.2 Background Ammonia Concentrations from APIS

KEY

- New Forest Designated Sites
- 200m buffer of roads

Ammonia Concentrations ($\mu g/m^3$)

- 0.730000 - 1.000000
- 1.000001 - 1.690000

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

MAP 5.3 2036 Percentage Changes in Annual Mean NOx Concentrations In-Combination

KEY

- New Forest Designated Sites
- 200m buffer of roads

2036 Percentage Changes in Annual Mean NOx Concentrations In-Combination - Max

- -5.950000
- 77.203468

SCALE: 1:110,000 at A3

0 1 2 3 4 5 Kilometres

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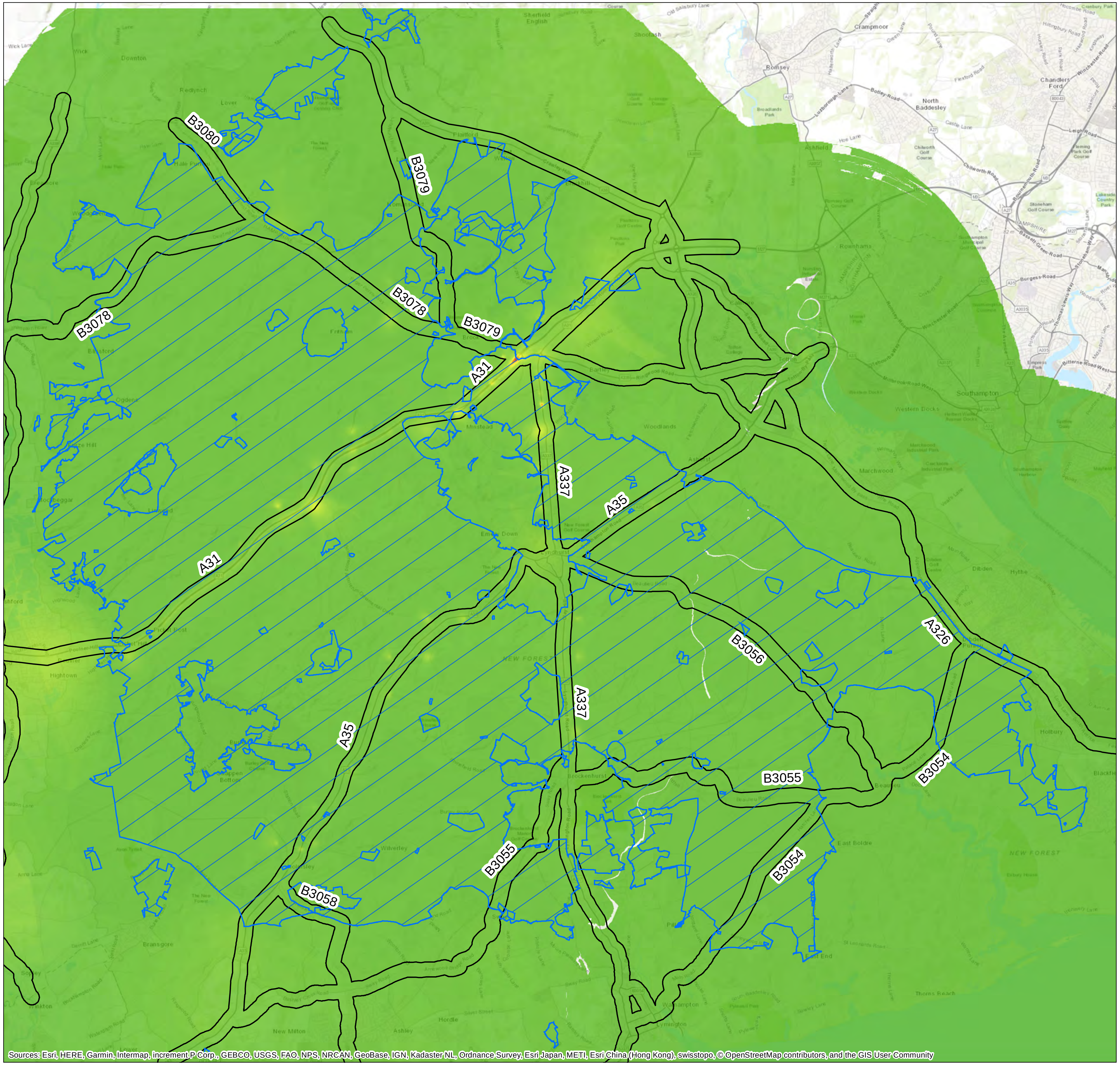

MAP 5.4 2036 Percentage Changes in Nitrogen Deposition Concentrations In-Combination

KEY

New Forest Designated Sites

200m buffer of roads

2036 Percentage Changes in NDep Concentrations In-Combination - Max

-0.460000

24.897924

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

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DATE: June 2018

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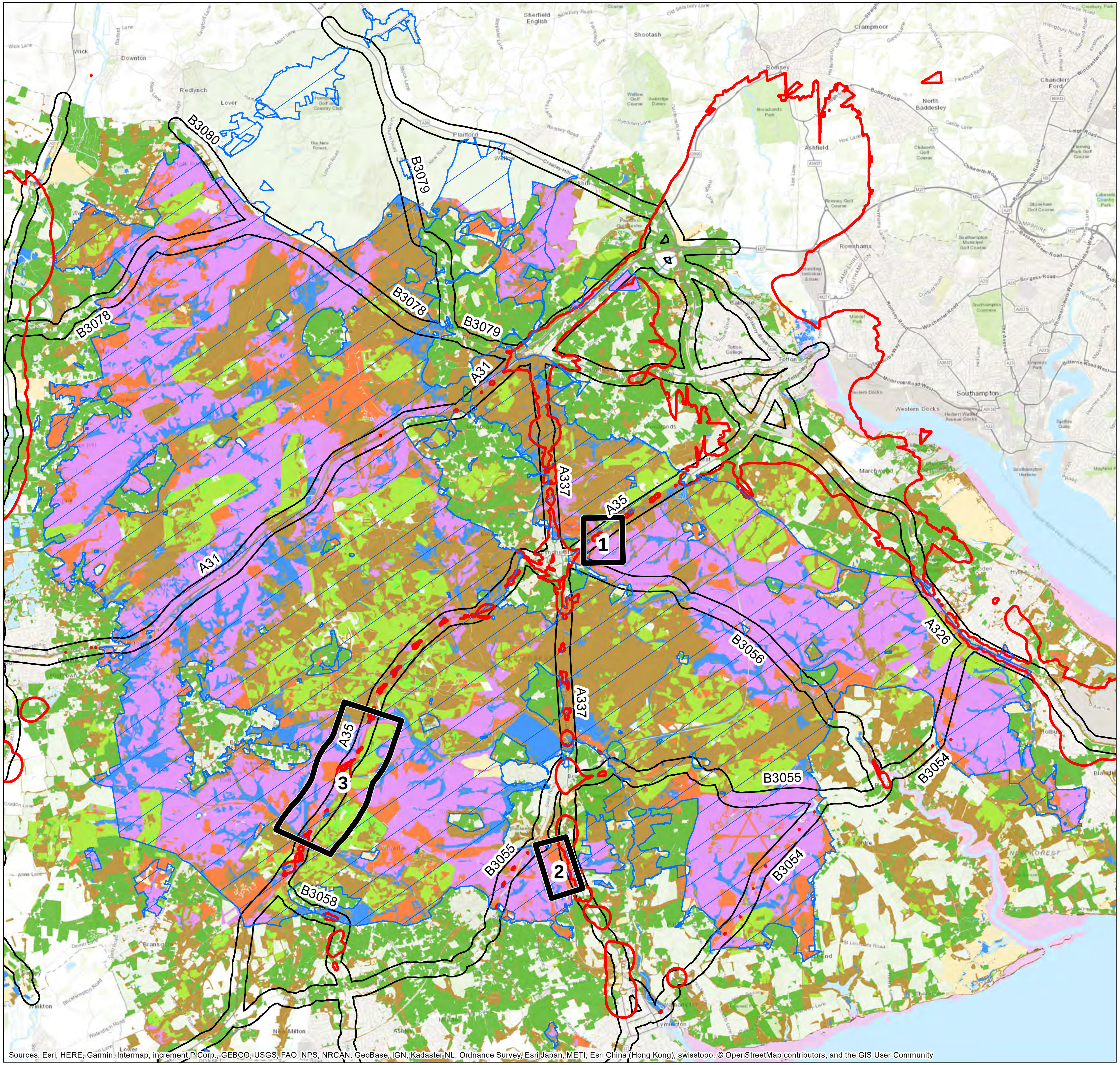


MAP 6.1 Proposed Monitoring Locations – Short Habitats

KEY

- New Forest Designated Sites
- 200m buffer of roads
- Proposed monitoring location
- 2036 Combined In-Combination Exceedance Areas for All Pollutants
- Acid Grassland
- Bracken
- Broadleaved
- Calc Grassland
- Con Woodland
- Dwarf Shrub Heath
- Fen Marsh
- Improved Grass
- Litt Sed
- Neutral Grassland
- Super Sediment

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

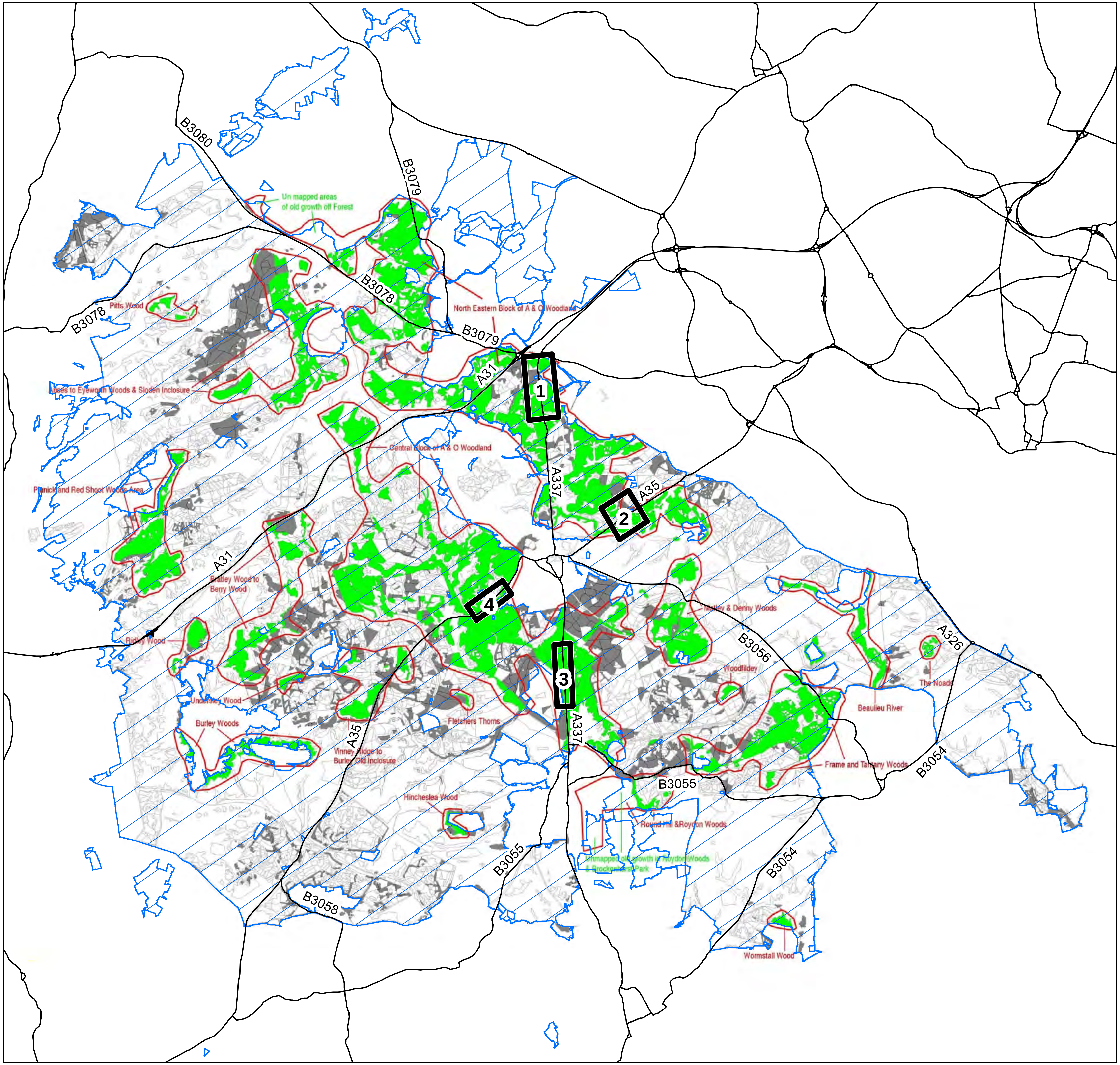
Ecological Planning & Research

CLIENT: New Forest District Council (NFDC) and New Forest National Park Authority (NFNPA)

PROJECT: New Forest Air Quality Assessment

DATE: June 2018

P18/13



MAP 6.2 Proposed Monitoring Locations – Tall Habitats

KEY

- New Forest Designated Sites
- Road network
- Proposed monitoring location
- Existing old growth woodland
- 19th Century broadleaved stands
- Lichen rich old growth meta-sites

The locations of the woodland areas shown on this map have been provided by Neil Sanderson from his personal data. The map is based on Sanderson (2007) and includes subsequent amendments.

Sanderson, N. A. (2007) New Forest Inclosure Habitats, Habitat Fragmentation & Landscape History. Botley: Hampshire & Isle of Wight Wildlife Trust.

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

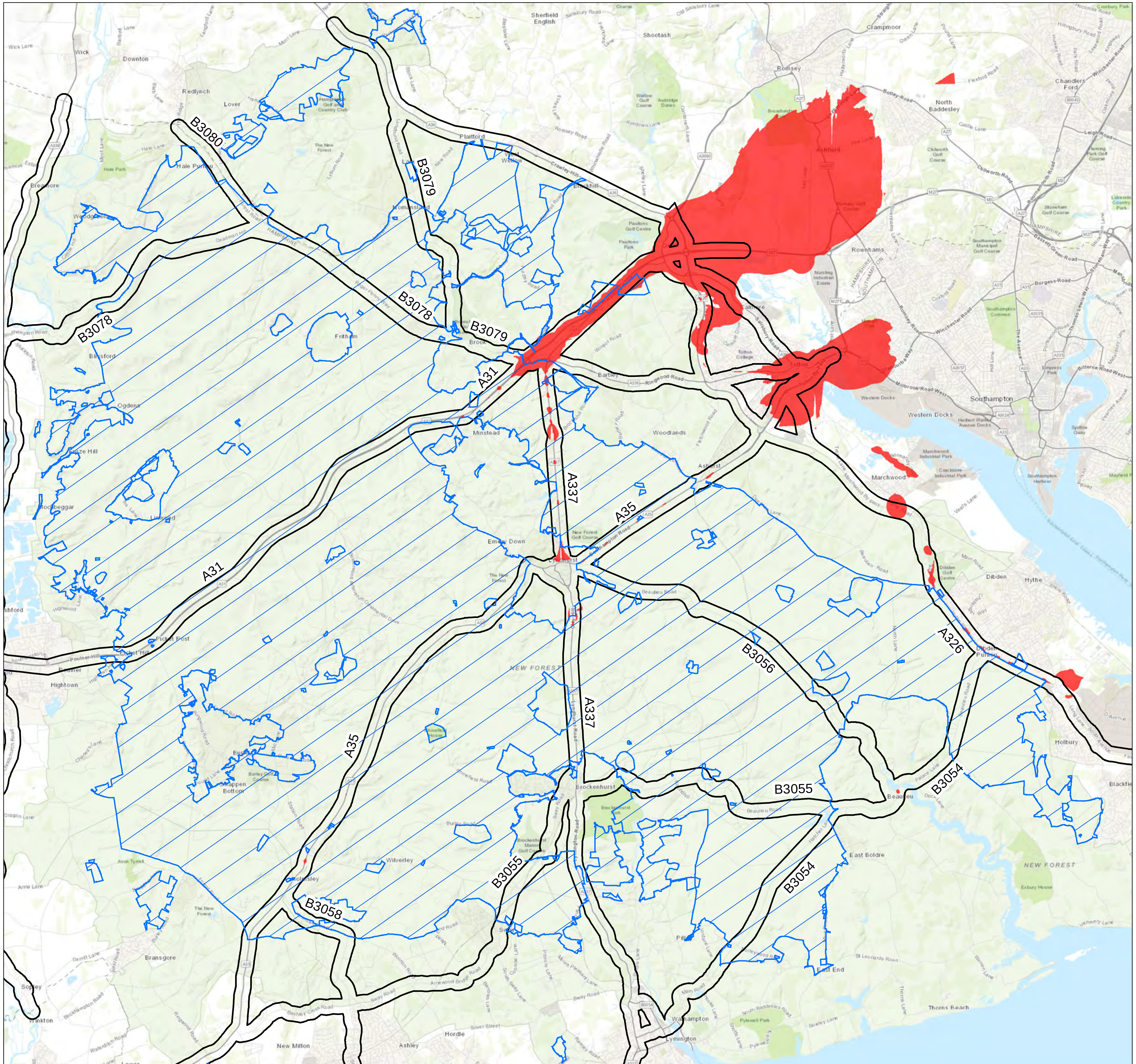
EPR
Ecological Planning & Research

CLIENT: New Forest District Council (NFDC) and New Forest National Park Authority (NFNPA)

PROJECT: New Forest Air Quality Assessment

DATE: June 2018

P18/13



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

MAP 7.1 2036 Combined Annual Mean NOx Areas where PEC exceeds 100% of CL and PC Exceeds 1% of CL

KEY

- New Forest Designated Sites
- 200m buffer of roads
- 2036 Combined Annual Mean NOx

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

Ecological Planning & Research

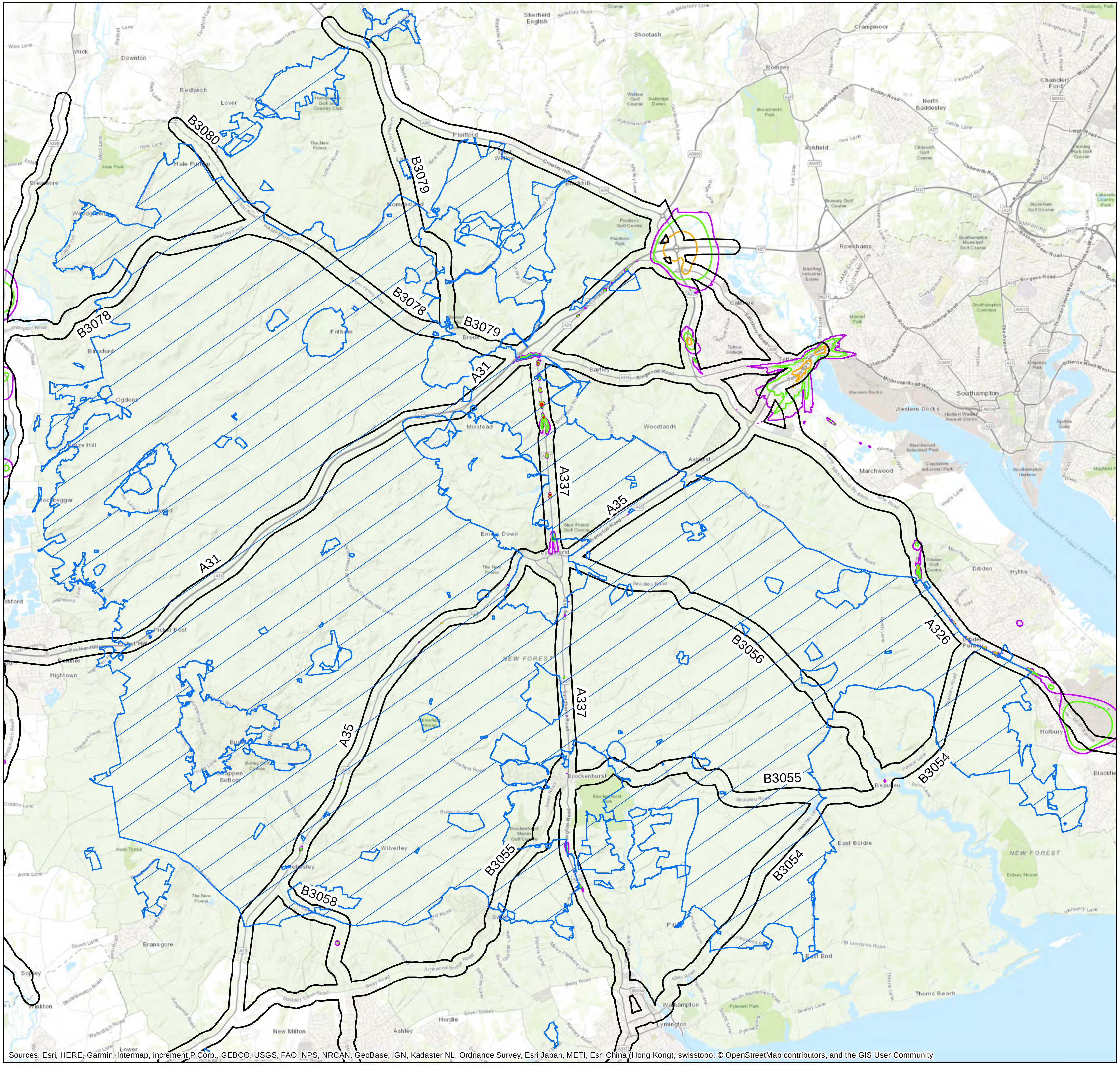
CLIENT: New Forest District Council (NFDC) and New Forest National Park Authority (NFNPA)

PROJECT: New Forest Air Quality Assessment

DATE: July 2018

Y:\New Forest Air Quality Assessment\GIS\Final Report\Map7_1_2036_Combined_Annual_Mean_NOx_P1813_310518.mxd

P18/13



MAP 7.2 2036 Grassland Combined NDep Areas where PEC exceeds 100% of CL and PC Exceeds 1% of CL

KEY

- New Forest Designated Sites
- 200m buffer of roads
- CL20
- CL15
- CL10
- CL8

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

Ecological Planning & Research

CLIENT: New Forest District Council (NFDC) and New Forest National Park Authority (NFNPA)

PROJECT: New Forest Air Quality Assessment

DATE: June 2018

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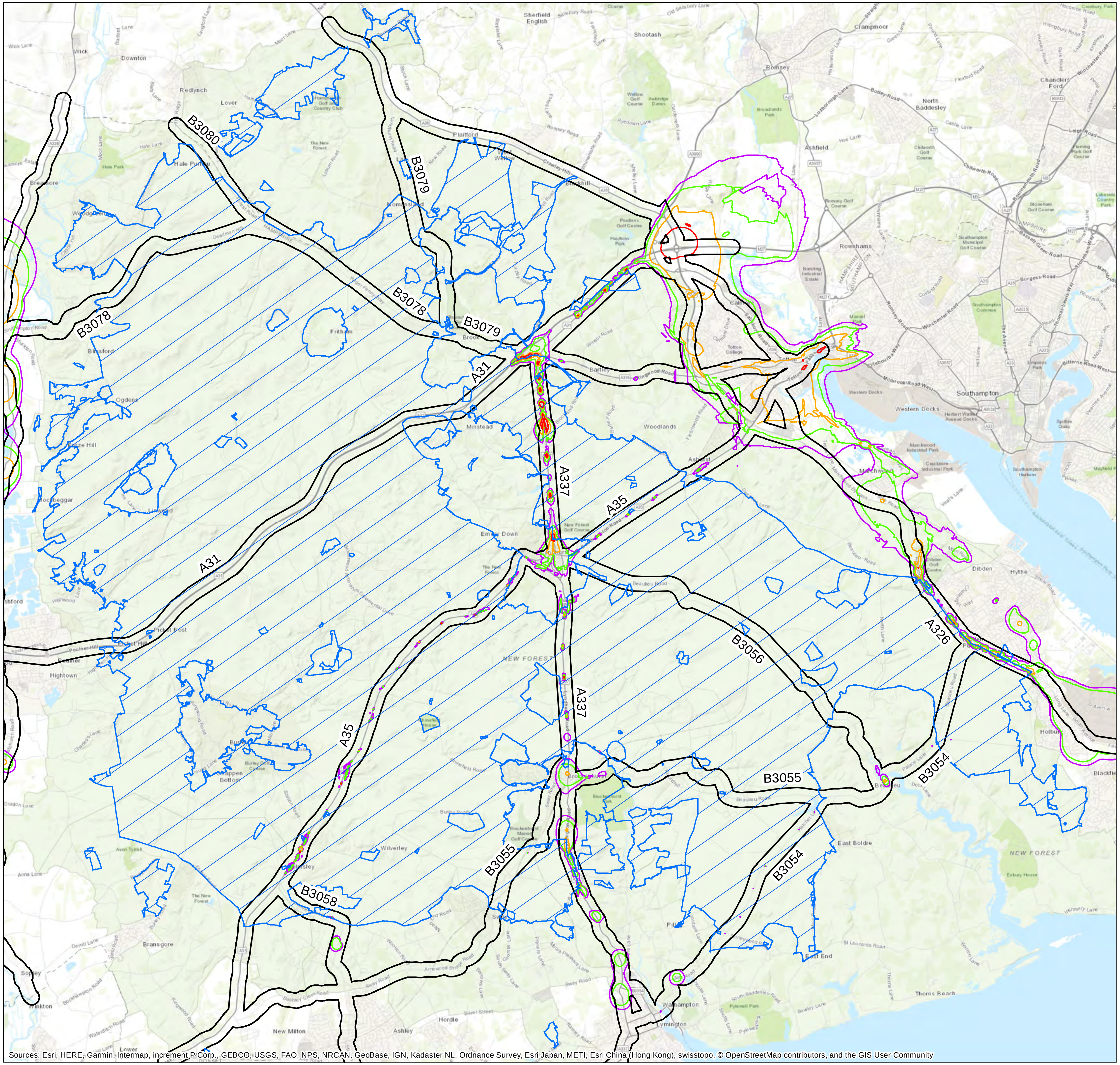

MAP 7.3 2036 Forest Combined NDep Areas where PEC exceeds 100% of CL and PC Exceeds 1% of CL

KEY

- New Forest Designated Sites
- 200m buffer of roads
- CL20
- CL15
- CL10
- CL8

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

Ecological Planning & Research

CLIENT: New Forest District Council (NFDC) and New Forest National Park Authority (NFNPA)

PROJECT: New Forest Air Quality Assessment

DATE: June 2018

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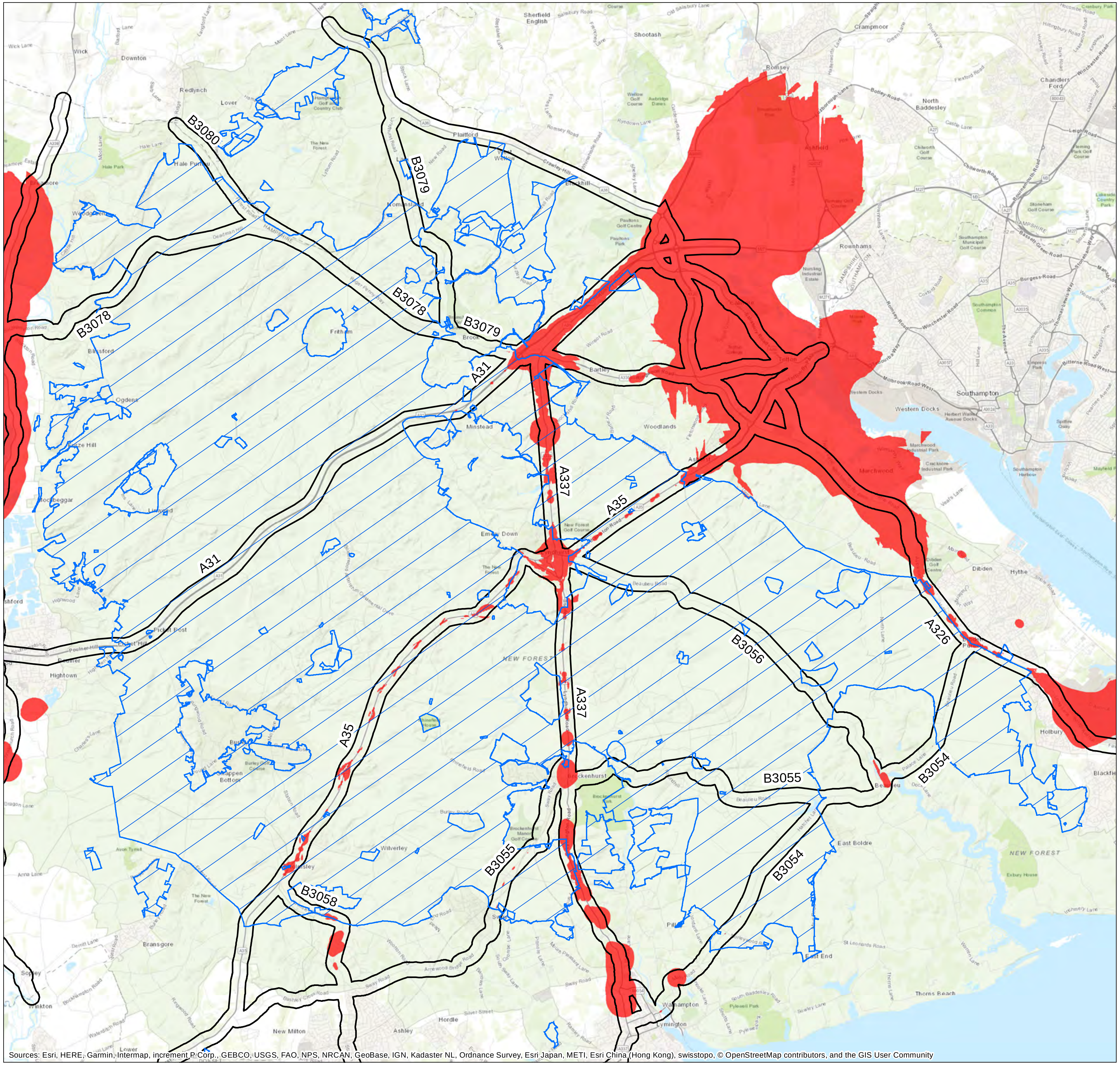


MAP 7.4 2036 Combined Ammonia Areas where PEC exceeds 100% of CL and PC Exceeds 1% of CL

KEY

- New Forest Designated Sites
- 200m buffer of roads
- 2036 Combined Ammonia

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

Ecological Planning & Research

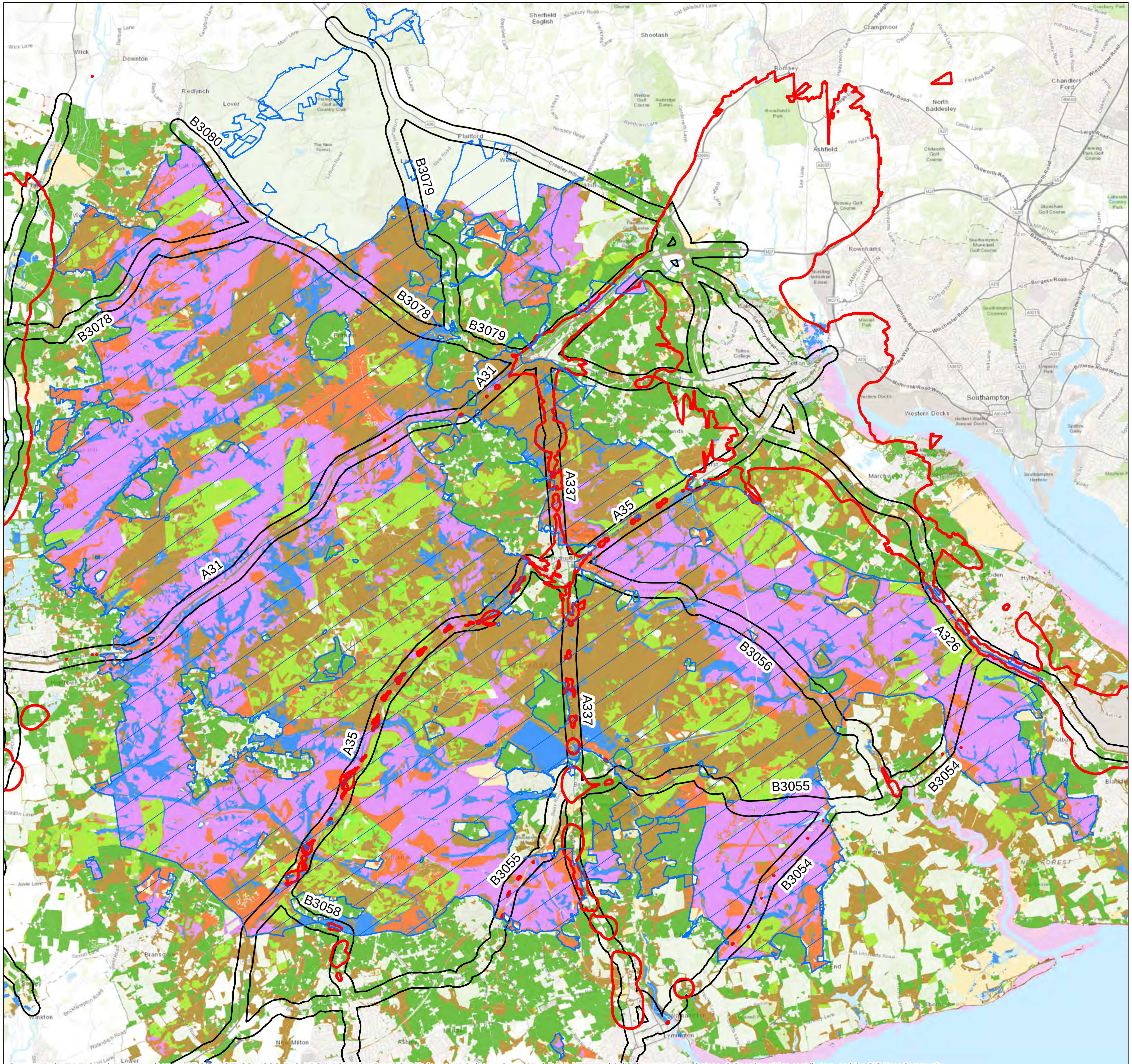
CLIENT: New Forest District Council (NFDC) and New Forest National Park Authority (NFNPA)

PROJECT: New Forest Air Quality Assessment

DATE: June 2018

Y:\New Forest Air Quality Assessment\GIS\Final Report\Map7_4_2036_Combined_Ammonia_P1813_310518.mxd

P18/13



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

MAP 7.5 Habitat Types within 2036 Combined In-Combination Exceedance Areas for All Pollutants

KEY

- New Forest Designated Sites
- 200m buffer of roads
- 2036 Combined In-Combination Exceedance Areas for All Pollutants
- Acid Grassland - 38.39 hectares*
- Bracken - 0.53 hectares*
- Broadleaved - 194.34 hectares*
- Calc Grassland - 0 hectares*
- Con Woodland - 14.22 hectares*
- Dwarf Shrub Heath - 48.16 hectares*
- Fen Marsh - 32.85 hectares*
- Improved Grass - 1.84 hectares*
- Litt Sed - 0 hectares*
- Neutral Grassland - 3.13 hectares*
- Super Sediment - 0 hectares*

* This is the area that falls within the 2036 Combined In-Combination Exceedance Areas for All Pollutants

SCALE: 1:100,000 at A3

0 1 2 3 4 5 Kilometres

N

EPR

Ecological Planning & Research

CLIENT: New Forest District Council (NFDC) and New Forest National Park Authority (NFNPA)

PROJECT: New Forest Air Quality Assessment

DATE: June 2018

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Appendix 1

Summary of Annex 1 Habitats Types / Critical Loads/Levels and Approach to Study

Table A1.1: Summary of Approach to Studying Annex 1 Habitats

Annex 1 Habitat Code	Annex 1 Habitat Title	Survey Strategy	Critical Load for Nutrient Nitrogen [Nitrogen Deposition] for New Forest	NO_X Annual Mean	NH_3 Annual Mean
			Kg N/ha/yr	Micrograms/ cubic metre	Micrograms/ cubic metre
3110	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)	These are small, localised habitats. Any present in the sample areas will be recorded and their species composition described	10 kg N/ha/yr.	30	Site specific advice should be sought
3130	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea	These are small, localised habitats. Any present in the sample areas will be recorded and their species composition described	10 kg N/ha/yr.	30	Site specific advice should be sought
4010	Northern Atlantic wet heaths with *Erica tetralix*	Transect Sampling	10 kg N/ha/yr.	30	1 (set for Lichens and Bryophytes)
4030	European dry heaths	Transect Sampling	10 kg N/ha/yr.	30	1 (set for Lichens and Bryophytes)

Annex 1 Habitat Code	Annex 1 Habitat Title	Survey Strategy	Critical Load for Nutrient Nitrogen [Nitrogen Deposition] for New Forest	NO_X Annual Mean	NH_3 Annual Mean
			Kg N/ha/yr	Micrograms/ cubic metre	Micrograms/ cubic metre
6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caerulae)	The locations of any of this habitat type will be recorded on the sampling area maps to see firstly whether the habitat is present and secondly whether any can be sampled by transect	15 kg N/ha/yr	30	Site specific advice should be sought
7140	Transition mires and quaking bogs	The locations of any of this habitat type will be recorded on the sampling area maps to see firstly whether the habitat is present and secondly whether any can be sampled by transect	10 kg N/ha/yr	30	1 (set for Lichens and Bryophytes)
7150	Depressions on peat substrates of the *Rhynchosporion*	This is a localised habitat, often very small and fragmented. If it is seen in the sample areas it will be recorded with its species composition. There will never be enough continuous 7150 habitat for transect work though it may be possible to find stands in a wider survey area at various distances from the road	10 kg N/ha/yr	30	1 (set for Lichens and Bryophytes)
7230	Alkaline fens	The locations of any of this habitat type will be recorded on the sampling area maps to see firstly whether the habitat is present and secondly whether any can be sampled by transect	20 kg N/ha/yr	30	1 (set for Lichens and Bryophytes)

<table>
<tr><th rowspan="2">Annex 1 Habitat Code</th><th rowspan="2">Annex 1 Habitat Title</th><th rowspan="2">Survey Strategy</th><th>Critical Load for Nutrient Nitrogen [Nitrogen Deposition] for New Forest</th><th>NO_X Annual Mean</th><th>NH_3 Annual Mean</th></tr>
<tr><th>Kg N/ha/yr</th><th>Micrograms/ cubic metre</th><th>Micrograms/ cubic metre</th></tr>
<tr><td>9120</td><td>Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion)</td><td rowspan="5">The locations of these woodland types within the 200m zone and just beyond will be identified (where relevant exceedances and contributions apply). Maps of the lichen-rich woodland meta-sites will be produced.

Woodlands are exceptionally complicated habitats to monitor and will rely on expert judgement to interpret modelled data and discuss risks associated with modelled scenarios, including potential impacts to lichen and bryophyte populations relevant to the SAC habitats.</td><td>10 kg N/ha/yr</td><td>30</td><td>Site specific advice should be sought</td></tr>
<tr><td>9130</td><td>Asperulo-Fagetum beech forests</td><td>10 kg N/ha/yr</td><td>30</td><td>Site specific advice should be sought</td></tr>
<tr><td>9190</td><td>Old acidophilous oak woods with Quercus robur on sandy plains</td><td>10 kg N/ha/yr</td><td>30</td><td>Site specific advice should be sought</td></tr>
<tr><td>91D0</td><td>Bog woodland</td><td>10 kg N/ha/yr</td><td>30</td><td>Site specific advice should be sought</td></tr>
<tr><td>91E0</td><td>Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)</td><td>Not Sensitive to Nitrogen Deposition</td><td>30</td><td>1 (set for Lichens and Bryophytes)</td></tr>
</table>

Appendix 2

Sanderson, N. (2003) *Notes on the 'Road Effect' on Heathlands*. A Review of Angold (1997)

NOTES ON THE 'ROAD EFFECT' ON HEATHLANDS

1.0 INTRODUCTION

1.1 Does a 'Road Effect' Exist?

The following note was written by Neil Sanderson in response to a paper by Angold in the Journal of Applied Science:

Angold, P.G. (1997) The impact of a road upon adjacent heathland vegetation: Effects on plant species composition. Journal of Applied Ecology 34, 409-417.

Angold (1997) shows a 'Road Effect' in terms of enhanced growth of grasses and a decrease in the of abundance of *Cladonia* lichens near roads in the New Forest. This is ascribed to emissions of nitrogen oxides from passing cars. The road effect was correlated with the amount of traffic carried by the road.

Although evidence of a road effect is produced, only weak evidence is given that nitrogen oxides cause the effect. Ingold then goes on largely to assume that NOx is the cause. Roads have other effects on the environment, however, that need investigation before this assumption can be remotely acceptable.

1.2 What are Roads?

1.2.1 Place in the Ecological Landscape

Heathlands are a cultural landscapes created by exploitation of low productivity and mainly acidic soils as extensive rangelands. These were normally managed as commons; as the New Forest still is. Commons were areas of land left open after the more fertile areas had been enclosed for arable crops or hay meadow. As such roads are inextricably linked with commons; in unenclosed parishes, all roads were part of the common. As such roads have always been associated with heaths. Until the 18th century heathlands roads were rarely constructed, they were simply tracks worn across the common land on the most convenient route. In places wide bands of hollow ways can been seen, marking such old routes. These are often picked by bands of Gorse were less leached subsoil has been exposed; such old routes can be marked by wide bands of soil disturbance.

By the 18th century turnpikes were being setup and roads constructed. In the New Forest constructed roads came particularly late as, on such a large common, it was difficult to fund turnpikes; it was easy to evade tolls. Not until the formation of the County Council in the late 19th century was efficient road building under taken on the Forest (Lascelles, 1915). These constructed roads are thought to have often incorporated Chalk, as well as local gravel, in their construction. In the 20th century these roads were surfaced with tarmac. The typical New Forest road across drier heathland has only a limited drainage system; it is simply raised to varying heights above the surface of the heath and water allowed to wash off onto the adjacent heathland through shallow ditches cut through raised verges. There is often an unmaintained ditch along the edge of the road verge. On plateaus these ditches do not discharge into any drainage systems but spill onto the heathland (**Photo 1**).

1.2.2 Biodiversity of Roads

Heathlands in the wide sense include more than just heather dominated heath. Heather dominated heaths are typically found on undisturbed strongly leached soils, usually Podzols, but many other communities occur. These other communities are an integral part of the heathlands and are very important for heathland biodiversity. These communities are found on soils which are either wetter, more productive and or less acidic. The communities on more productive soils are typically more dependant on continued grazing to maintain condition. As such, species associated with these communities have become rare within ungrazed heaths (Byfield & Pearman, 1995). Some of the species declining on ungrazed heaths include those specifically associated with the disturbance of traditional unconstructed tracks, especially rutting, these including *Anagallis minima*, *Cicendia filiformis*, *Mentha* *pulegium*, *Pulicaria vulgaris* and *Radiola linoides* (Byfield & Pearman, 1995). These species are associated with open ground on seasonally wet productive soils. Some of these can also be found associated with constructed roadside ditches, including *Cicendia filiformis*, in both the New Forest and by the B3075 in Dorset and *Mentha pulegium* in the New Forest. Marsh Club Moss *Lycopodiella inundata* in contrast is associated with very acidic nutrient poor shallow poached peat often along unsurfaced tracks but never constructed roads.

The verges of unfenced constructed roads in the New Forest are typically composed very mixed and varied grasslands. These are clearly influenced by the higher pH of the imported construction material and include communities varying between <u>Festuca – Agrostis – Rumex acetosella Grassland Anthoxanthum – Lotus/Hypochaeris sub-communities</u> (U1d/f) and <u>Lolium – Cynosurus Grassland Anthoxanthum sub-community</u> (MG6b) on dry ground. Ditches and soakways fed from the road support wet grasslands (<u>Juncus acutiformis – Galium palustre Grassland</u>, M23a & <u>Molinia – Cirsium dissectum Fen Meadow</u>, M24c) and various ephemeral pond communities. Beyond the ditch there is usually a belt of acid grassland (<u>Festuca – Agrostis – Rumex acetosella Grassland Hypochaeris sub-community</u> U1f or <u>Agrostis curtisii Grassland</u>, U3), often with grazed down Heather, grading into Heather dominated heath (mostly <u>Calluna – Ulex minor, Molinia sub-community</u>, H2c & <u>Ulex minor – Agrostis curtisii Heath, typical sub-community</u>, H3a) indistinguishable from the wider heaths. The traditional track species described above, when associated with constructed roads are found in the ditches and soakways. The verges support a remarkable number of species of conservation interest, including parched Acid Grassland species such as the Nationally Scarce Wild Chamomile *Chamaemelum nobile*, Upright Chickweed *Moenchia erecta*, the Nationally Scarce grass *Vulpia ciliata ambigua* and several annual clover species including *Trifolium subterraneum*, *Trifolium ornithopodioides*, *Trifolium glomeratum*, *Trifolium striatum* and *Trifolium scabrum*. Locally high pHs bring in lime loving species such as Quaking Grass *Briza media*, Carline Thistle *Carlina vulgaris*, Stemless Thistle *Cirsium acaule* and Felwort *Gentianella amarella*. The zone of grassy heath beyond is usually less distinct floristically but declining species such as Lesser Butterfly Orchid *Platanthera bifolia* and the Nationally Scarce sedge *Carex montana* occur rarely.

1.2.2 Field Observations

The heathland adjacent to the B3078 was examined on the 28th March 2003 to gain an initial indication of the vegetation pattern along the roads. The main A31 was further examined on the 1st April.

Photo 1 shows a typical roadside transition on the B3078 at Longcross Plain (SU248153). The verge and ditches supported Parched Acid Grassland (U1d/f) grading into ephemeral pond communities (OV35) in the ditch (Zone 1). The later extend along soakways into the heath. The soils here are slightly acidic with pHs ranging from 6.5 by the road through to about 5.5. Beyond the ditch is a band of Heathy Acid Grassland (U3) with heavily browsed Heathers on moderately acidic soils (pH 5.0) (Zone 2). At about 15m this merges into Heather dominated Heath (H2c) on strongly acidic soils (pH < 4.5) (Zone 3). Beyond this at several sites along the B3078 no visible road effect could be seen any where by the author beyond the edge of Zone 2. Within Zone 3 heaths there is much variation in *Molinia* vigour and *Cladonia* density but these show no obvious relationship with the road but do show clear relations to soil (wetness and the parent material, especially the presence of head deposits), and burning history.

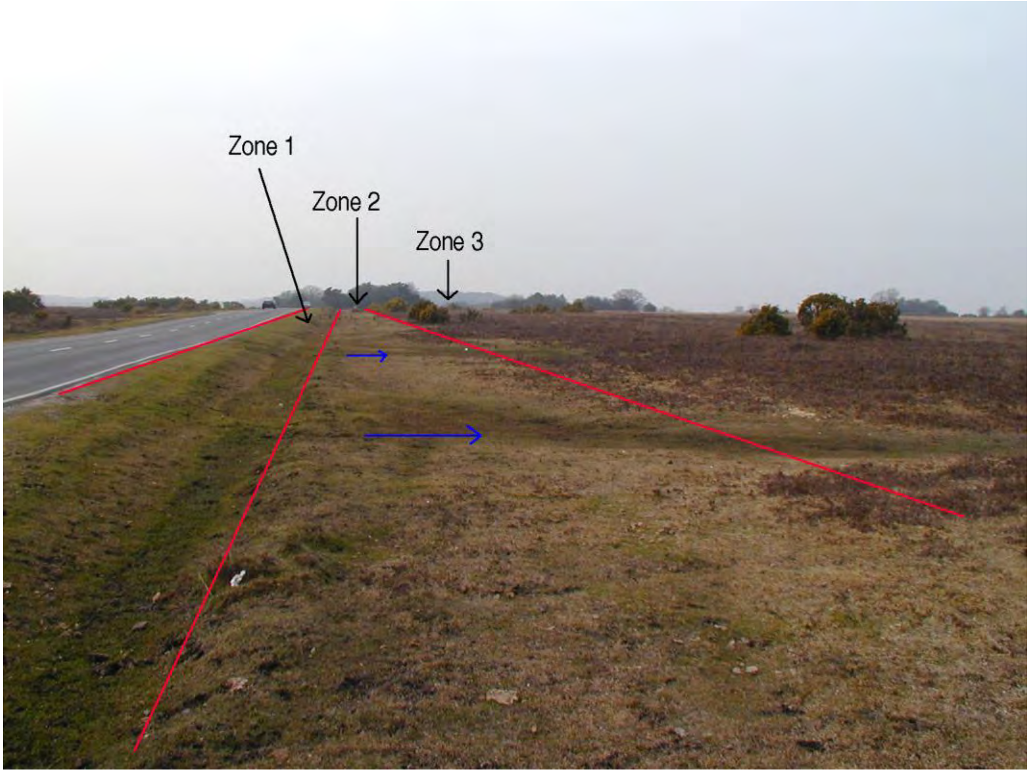


Photo 1. The road/heathland interface at Longcross Plain on the B3078. Zone 1 has species rich grassland (U1d/f) with slightly acidic soils and ephemeral pond communities (OV35) in the unmaintained ditch below. This drains off into the heath, as marked by the blue arrows. Zone 3 is an area of heavily grazed Heath Acid Grassland (U3) on moderately acidic soils which grades into typical heaths (H2c) about 15m from the road (Zone 3) on strongly acidic soils.

The same transitions can be seen where areas of productive grazing, such as village greens, grades into low productivity heaths. The author could see no obvious difference between the changes from the road verge to heath than from productive grassland to heath.

There was clearly greater grazing pressure nearer to the road all along the B3078 and to get an indication of the difference in intensity, two transects 100m long were made one 10m from the road and one 100m in at Deadman Hill (SU208147). Along these transects all the visible droppings were counted (all pony). The transect nearest the road was through grassy heath (H3a & U3) and was seamed with pony paths and 52 separate droppings seen. Away from the road the transect was through senescent Humid Heath (H2c). Only one pony path crossed the transect and only two pony droppings were seen. This suggests that the grazing intensity here was much higher along the road.

Along the A31 the vegetation pattern is similar, except the verges with the most enriched Zone 1 vegetation is fenced off and ungrazed. In one interesting area at Fritham Cross (SU237098), the new dual carriageway was built along a new alignment. The original pre 1960s road has had the tarmac removed (**Photo 2**) but still has similar zoning as seen along the B3078. The edge between Zone 2 Heathy Acid Grassland (U3) and unaffected H2c heath is 16m from the original edge of the tarmac. About 40 years of abandonment has made no visible difference to the vegetation zonation beside the abandoned road.

Along the modern road grazing pressure was less evident than on unfenced minor roads but a strip along the fence is mown for fire safety and access and this has produced a similar Zone 2 strip of Heathy Acid Grassland (U3) in places (**Photo 3**). Where there was no mowing, especially on the new section of road at Fritham Cross (SU237102), unaltered heath vegetation reached right to the road fence (**Photo 4**). Also seen locally were hollow ways indicating former multi-tracking before the construction of modern roads (**Photos 5** & **6**) while it was noted that controlled fires were burned short of the road fence (**Photo 7**).

Photo 2. Photo taken standing on the original A31 at Fritham Cross (SU237098). Even after 40 years there is still a 16m wide zone of disturbed grassland with Parched Acid Grassland (U1f) on the verge and Heath Acid Grassland (U3) with Bracken beyond.

Photo 3. Photo taken on the south side of the A31 at Handy Cross (SU214080). The strip against the fence is mown for fire safety and access reasons. This produces a sharply defined Zone 2 of Heathy Acid Grassland (U3) with Heath (H2c & H3a) beyond.

Photo 4. Photo taken on the south side of the A31 at Fritham Cross (SU237102). Here the new road is sunk in a cutting. There is no visible effect on the undisturbed heath on the Forest side of the fence.

Photo 5. Photo taken on the south side of the A31 at Handy Cross (SU218075). An ancient hollow way pre dating the 19th century road. The disturbed ground has grassy heath (U3 & H3).

Photo 6. Photo taken on the north side of the A31 at Handy Cross (SU202071). Multi-tracking is visible as shallow hollow ways. This probably pre dates the original 19th century road. The disturbed ground has grassy heath (U3 & H3).

Photo 7. Photo taken on the south side of the A31 at Handy Cross (SU205073). Here a controlled burn was carried out, with the trace cut about 25m beyond the road fence.

1.3 Factors Involved

1.3.1 Road Construction

The base of the roads on the forest are thought include chalk in their construction and material such as limestone chippings are used on the road surface. This imported material is the probable source of the high soil pHs found in Zone 1. The slightly raised pHs in Zone 2 on the B 3078 may also be due to wash from Zone 1. Road dust washed and blown of the road and have a similar effect to the limestone and chalk.

1.3.2 Differential Grazing Pressure

The establishment of sweeter grazing on the road verges in Zone 1 brings in more stock on unfenced roads. The stock also use the road and its verges as convenient routes for getting around their home ranges. This results in increasing grazing pressure on the adjacent poorer heaths adjacent. The dung count transects along the B3078 suggest this grazing pressure can dramatically higher close to the road.

This concentration of stock results in transfers of nutrients as herbivore droppings and urine from the low quality grazings on to areas of better quality grazing. This localised concentration of nutrients is well known in the New Forest ecology and has resulted in the creation of sizable greens near villages where heath would otherwise occur (Tubbs, 2001). In addition a typical phenomena is the heavy grazing pressure on low productivity communities immediately adjacent to productive grazings. May rare early succession species that require short *Calluna* heath have significant populations in such areas.

The initial impression is than the Heathy Acid Grasslands and short grassy Heath often seen in Zone 2 are mainly created by a combination of heavy grazing and some nutrient enrichment from the stock. Identical zonations through grassy heath to *Calluna* dominated heath can be seen on the New Forest adjacent to medieval village greens and areas formerly cultivated in WWII and then reseeded.

1.3.3 Fire

Fire is a major factor in heathlands, both controlled fire as part of planned management and wild fire. In the New Forest with a large scale programme of controlled burning, significant wild fires are rarer than on most lowland heathlands. The burning is carried out to provide a flush of nutritious grazing; to remove old course vegetation, young trees and litter; to produce a mosaic of age classes of heath and to reduce the likelihood of wild fire. Conservationists often regard fire negatively but it is in fact an integral part of the heathland ecosystem and numerous species are fire dependant. This includes lichens, which are late succession fire dependant species. That is fires destroy them initially, but the fires themselves create suitable habitat for recolonisation in the latter stages of regrowth. Without burning lichen species diversity and cover declines in the long term (Sanderson, 1996).

Fire has major effects on nutrient cycling with *Calluna* heath. Webb (1998) in describing the effects of heath fires states that 95% of nitrogen and 20 – 30% of other principle plant nutrients in the standing crop and accumulated litter. Losses of sodium, potassium, calcium and magnesium can be replenished from precipitation within a few years but losses of phosphorus and nitrogen cannot. 20 years are estimated for the recovery of phosphorus. Nitrogen levels may take longer to recover in the absence of nitrogen fixers such as Gorse (Webb, 1998). This impact of fire on nitrogen cycling is probably fundamental to the establishment of heathland in the first place and Webb has expressed concern that fire suppression could be as serious a threat to heath conservation as nitrogen deposition.

On the New Forest controlled fires are usual set to avoid burning right up to the roads for safety reasons and because there is less to burn in Zone 2 any way. Even wild fires usually leave Zone 2 unburned due to lower fuel load. This increased frequency of burning away from the area of both heaviest grazing and dung/urine deposition is likely to be enhancing productivity difference between the heathland close to and further from the road.

1.3.4 Mowing

Along parts of some roads a strip beyond the verge is mown, especially the A31 and the 3054. Along the fenced A31 this is done for fire safety and access and for visibility along the unfenced roads. The result of regular mowing is to reduce the heather cover and increase the grass cover. As this attracts in more grazing and a feedback is produced with increased grazing promoting grass cover. Generally Heathy Acid Grassland (U3) is created.

1.3.5 Nitrogen Deposition

Obviously traffic will be adding some nitrogen deposition to this complex ecosystem but whether this is significant must be questioned. The subjective observation that similar zonations can been seen by long abandoned roads or adjacent to areas where sweeter grazing abuts on to low productivity heaths suggests greater caution is required in attributing difference in heathland vegetation along roads as being purely due to nitrogen deposition from traffic.

1.3.6 The B3075 Dorset

The author carried out both general vegetation survey along the 3075 in Dorset and specific examination of the Red Data Book species Yellow Century *Cicendia filiformis* for EPR. The Great Ovens heath area is no longer grazed but parallels can be seen with the New Forest heathland roads. High pH material (calcium rich clay) has clearly been used in the original road construction, either imported or exposed by excavation and there is well defined Zone 1 on enriched soils on the verges. Without grazing these are mainly colonised by Sallow scrub or Gorse but herb rich grasslands survive locally where disturbance had maintained open communities.

Beyond this there is also a clear Zone 2 but here this was being maintained by harrowing or ploughing fire breaks parallel to the road, rather than by grazing or mowing. The result is much bare ground with incipient grass and heather colonisation. Especially interesting on the west side were large colonies of the rare and declining *Cicendia filiformis* in areas where enriched water from simple road drainage was discharged directly on to the heathland into areas that were regularly cut and disturbed as a fire break. Here this species was totally dependant on the raised productivity produced by this ‘polluted’ water combined with regular disturbance. This species is a classic track way species.

Beyond this disturbed zone (about 20m from road?) there is no easily discernable effect on the *Calluna* dominated heathland.

1.3.7 Significance

That roads have a considerable effect on heathland vegetation cannot be doubted, as **Photo 1** clearly illustrates. This effect should be regarded as a characteristic part of the heathland cultural landscape and road verges can form important biodiversity hot spots. There are clearly massive differences between an old road on an ancient route in use since the Iron Age and a totally new road being driven through long undisturbed heathland.

A holistic view of the heathland habitat must encompass the subsidiary habitats as well as Heather dominated habitats specifically mentioned in the Habitats Directive. The health of the heathland ecosystem can not simple be assessed on the condition of the major vegetation types as emphasised by the results of the studies of Byfield & Pearman (1995). In this view, existing roads are an important part of the heathland ecosystem, with nutrient enrichment, whatever its source, a positive feature. A new road is a completely different issue and the two should not be confused. It must be noted that many features of the New Forest roads would probably not be allowed in modern road construction across heathland SSSIs, especially the use of calcareous material and drainage systems that discharge directly on to heathland surface.

2.0 COMMENTS ON ANGOLD (1997)

2.1 Introduction

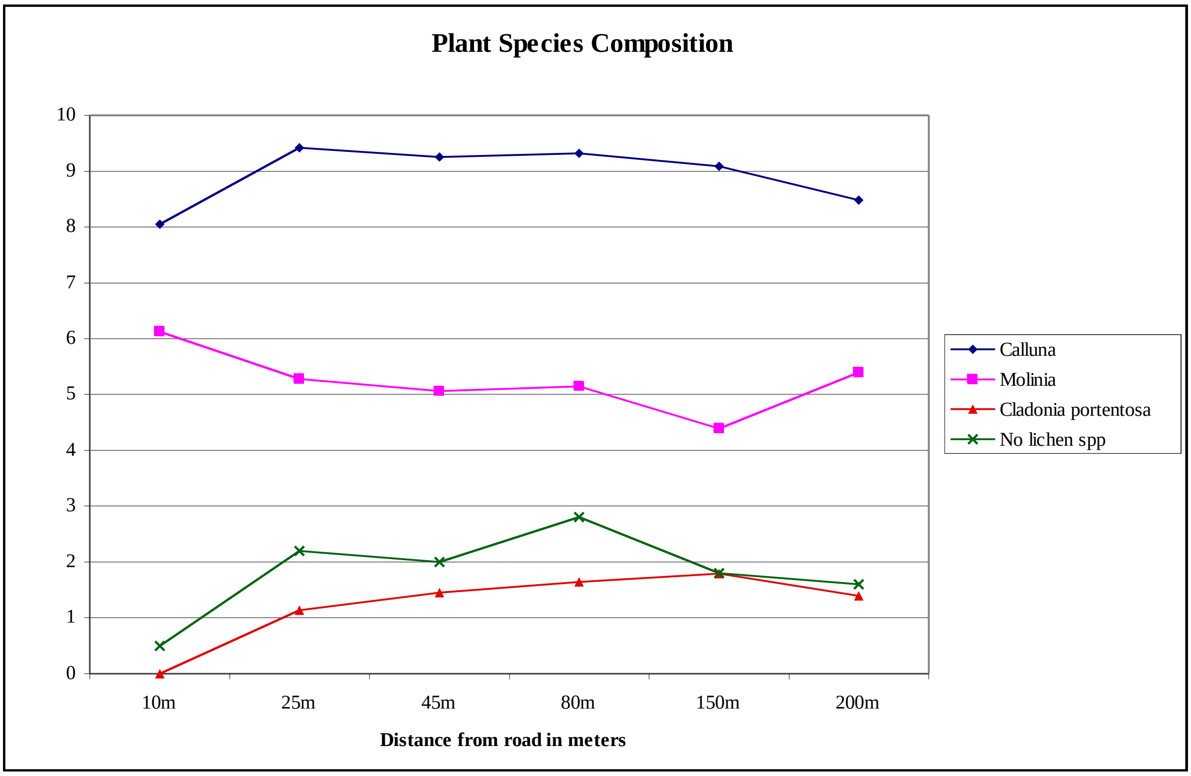
The results of Angold (1997) are discussed in the light of the above observations.

2.2 Results

2.2.1 Plant Species Composition

The plant species composition was recorded along a series of transects 10, 25, 45, 80, 150 and 200m from the road. Although quite a few significant treads are highlighted by DECORANA regression it pays to look at the original data carefully (**Chart 1**). This shows the strongest effects are 10m from the road, within Zone 2, where there are multiple factors including calcium input, high grazing pressure, associated dung/urine deposition and low fire occurrence as well as any nitrogen deposition. All of these will tend to produce the higher *Molinia* cover and lower Heather and lichen cover and diversity observed. The pattern beyond this is less than convincing; this appears to reflect the lack of obvious effect in the field observed by the author.

CHART 1



2.2.2 Plant Performance

Significant increase growth is shown for *Calluna* and *Molinia* nearer the road and similar significant increased *Nitrogen* and *Phosphorus* levels in *Calluna*, but not in the *Molinia*. These increases could be equally credited to inputs other than nitrogen from traffic. Elevated phosphorus levels in particular appears unlikely to have any link to traffic but could reflect increased animal dung deposition. Interestingly the *Molinia* transplants show no significant difference in tissue nitrogen content, but the plants near the road grew more strongly, were greener and had higher tissue phosphorus content. Again this appears more likely to reflect increase dung deposition than nitrogen from traffic.

For *Cladonia* only the stem height decreased significantly near to the road. This parameter is as likely related to sward height and trampling intensity as any nutrient inputs.

2.2.3 Correlation with Traffic Density

The only evidence presented that the above effects are connected with pollution from traffic is a significant correlation between the extent of the 'edge effect' and the density of the traffic. This edge effect, however, was not an objective measure but appears to be a subjective judgment. As such the wide edge effect is not one that the author can see (it may be a bit more evident in summer when the *Molinia* is green). Beyond Zone 2 (15 – 20m at most) no easily observable edge effect can be seen.

2.2.4 Angold's Discussion

In much of the discussion the weakness of the evidence is apparent; most of the discussion qualifies inferred nitrogen effects with words such as 'may'. The increases in phosphorous, which are more noticeable in the results, is dismissed as possibly originating from 'litter from the road'! A more likely origin is from animal dung.

The role of grazing by stock appears barely appreciated and bizarrely invertebrates are assumed to be the main herbivores of *Molinia* with only 'some' predation attributed to ponies. This indicates a complete failure to appreciate the level of stock grazing pressure in the area. Interestingly herbivore pressure is mentioned as being highest by lay-bys on the A31. From personal experience a further nitrogen input here is human and dog urine!

3.0 FURTHER ACTION

This needs further discussion. Ideally the nitrogen input from the traffic levels involved would be interesting and also, if at all possible, rough calculations of nitrogen and phosphorous inputs from pony and cattle defecation.

The source of the increased phosphorus levels is probably a particular weakness of the evidence in Angold (1997).

Any fieldwork could look at the soil much more intensively and at a wider range of nutrients including elements such as phosphorous (an indication of the input from stock) and calcium (a measure of the contribution of road construction). Objective measurements of any edge effect are also required. Finally this work should be repeated along abandoned roads and across gradients between productive soils and oligotrophic soils away from roads.

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NEIL SANDERSON
Botanical Survey and
Assessment
----
3 Green Close
Woodlands
Southampton
Hampshire
SO40 7HU
023 8029 3671 (Phone & Fax)
07765 648149 (Mobile)
Email: neilsand@dircon.co.uk

Report written for Ecological Planning & Research March 2003 by Neil A Sanderson

Appendix 2a

Webb, N (1998) Conference Note – the Role of Fire in the Ecology of Heathland in Southern Britain

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• The Role of Fire in the Ecology of Heathland in Southern Britain

• **(IFFN No. 18 - January 1998, p. 80-81)**

• Heathlands dominated by ericaceous dwarf shrubs are widespread on acid nutrient-poor soils throughout those regions of north-western Europe with an Atlantic climate. They developed c. 4000 years ago following forest clearances and have been maintained by grazing, burning, turf (sod) cutting, and the gathering of vegetation for fuel. These activities arrest succession to scrub and woodland (Webb 1986). Heathland is burnt to improve the forage for grazing stock but some fires are uncontrolled and wildfires may occur.

• Heathlands show some of the characteristics of a fire climax (Gimingham et al. 1979). The dominant species *Calluna vulgaris* regenerates freely from the stem bases when burnt and the germination of its seeds is promoted by heat. Regular burning reduces the floristic composition of heathland and species which regenerate from underground organs or rapidly from seeds (eg. *Calluna vulgaris*, *Erica tetralix*, *Vaccinium myrtillus*, *Deschampsia flexuosa*, *Molinia caerulea*, *Scirpus cespitosus* and *Pteridium aquilinum*) tend to dominate. Species such as *Juniperus communis* are eliminated by regular burning (Gimingham 1972).

• During heathland fires about 95% of the nitrogen and 20-30% of the other principal plant nutrients in the standing crop and accumulated litter are lost from the system. Losses of Na, K, Ca and Mg can be replenished from precipitation within a few years but the losses of P and N cannot. Phosphorus is held in the soil organic matter, and where the adsorption capacity is low, some of the P released during the fire is lost through leaching. It takes c. 20 years for P to be replaced (Chapman et al. 1989). The nitrogen budget is not fully understood. Because losses during a fire cannot be made up through rainfall, nitrogen-fixing plants (*Ulex* spp.) may be important (Chapman and Webb 1978).

• Where the fire has not been too hot *Calluna* regenerates from the stem bases and within three years enters the building phase. If the roots are killed regeneration is from seed giving a true pioneer phase, but taking longer before the building phase is reached. Over the 30-40 years of heath growth production increases but declines from about 20 years and onwards. The structure of the vegetation affects the microclimate during this process. At first, the canopy is open and the soil and litter surface dry with extremes of temperature. During the mature phase when the canopy is more or less complete, humid, still conditions with small fluctuations of temperature prevail. As the canopy opens during the late mature and degenerate phases more extreme conditions occur again.

- Heathland managed by burning consists of stands of a uniform age where the bushes all have the same structure. Other forms of management create mixed-age stands where bushes of different structure grow side by side. The invertebrate fauna is dependent on the structure of the *Calluna* bushes and there is a positive relationship between invertebrate diversity and the structural diversity of the vegetation. For some ground living species (eg. ants; Hymenoptera: Formicidae) this relationship may be negative as the developing vegetation canopy reduces insolation. After a fire there is a well-marked succession of species, with some species being characteristic of the early stages and others characteristic of the mature and degenerate phases. Spiders (Araneae) and ground beetles (Coleoptera: Carabidae) are typical examples. The soil fauna is dependent on soil moisture and the presence of plant litter. After a fire the development of the fauna is closely associated with the recovery of the heathland vegetation (Webb 1994). During a fire soil temperatures are <45° C because of the good insulating properties of the litter layer. Few animals are killed by the fire; however, populations decline rapidly once the vegetation canopy has been removed because the litter becomes very dry and blows away. A new layer begins to form only when the plant canopy closes c.10 years after the fire.
- Heather moorland in the north of England and Scotland is burnt every 12-15 years to provide nutritious young heather shoots for sheep and grouse. Grouse moors are burnt in strips because grouse require young heather for food and taller old heather for nesting and a supply of invertebrate food for their chicks. The management aims for these moors are very clear, but for lowland heathland conservation Chapman and Webb (1978) have suggested burning every 20 years. This cycle matches the replacement rate of nutrients, particularly P, by rainfall. Although the 20-year cycle matches nutrient inputs, too large a fuel load develops causing hotter fires and affecting plant succession. Fire temperatures depend more on conditions (moisture, rainfall, wind) at the time of burning, than on fuel load (Allchin et al. 1996).
- Accidental fires are common with peaks in their numbers during holiday periods in April and August. Most of the accidental fires occur near the urban areas and because of this there has been a reluctance to use controlled burning for heathland management. Strict fire protection measures have been implemented over the last 20 years and in Dorset the area burnt has declined from 1071 ha in 1978 to 451 ha in 1987. Until recently, when grazing has been introduced, fire has almost been the factor controlling succession. Because of the decline in burning the extent of scrub increased by 15% between 1978-87 (Webb 1990).
- In the very hot dry summer of 1976 eleven percent of the Dorset heathlands was burnt. A landscape scale analysis over the period 1978-1987 (Bullock and Webb 1995) showed that neither the extent nor the composition of the principal heathland types was affected by these fires. The only long-term effect was in the species composition of scrub. The fires had conserved the dynamic mosaic of the heathland vegetation types by preventing the succession of heathland to scrub and by reducing the cover of woodland. At large temporal and spatial scales the heathland landscape remained stable despite catastrophic disturbance at specific locations.
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From: *Nigel R. Webb*

Address: *Furzebrook Research Station*
Wareham
GB - Dorset BH20 5AS

Fax: ++44-1-929-551-087
Tel: ++44-1-929-551-518
e-mail: N.Webb@ite.ac.uk

Appendix 3

Sanderson, N. (2018) *New Forest Air Quality Study: Notes on Pollution Impacts on Annex 1 Woodland Habitats*

New Forest Air Quality Study

Notes on Pollution Impacts on Annex 1 Woodland Habitat

Background

The Resource and its Value
The core of the New Forest SAC woodlands interest are the extensive old growth pasture woodlands, found both on the open Forest and as relics and recovering stands within the Inclosures (Tubbs, 2001). These cover just under 3000ha (Flower & Tubbs, 1982) and as such are the largest area of such habitat in lowland western Europe (Rose, 1992 & Tubbs, 2001). They are exceptionally rich in biodiversity associated with woodland veteran trees (Tubbs, 2001), including invertebrates (Harding & Rose, 1986), fungi (Ainsworth, 2004) and lichens (Rose & James, 1974 & Sanderson, 2010). These features are all of international importance in their own rights and are an integral part of the interest of the SAC woodlands. As well as these unique features, which are most strongly developed in the old growth pasture woodlands, important assemblages of other groups also occur. These, however, usually occur equally in young growth stands and are less distinctive features of the New Forest SAC.

The extent of woodland habitat of high conservation interest in the New Forest can be measured by the extent of ancient woodland, i.e. woodland presumed to have been in existent since before 1600 (**Map 1**). This however, includes both young growth woodland and old growth woodland with very different biodiversity assemblages. The core areas of interest, however, are strongly associated with old growth woodland, i.e. extant stands originating in the 18th century or earlier (**Map 2**).

Pollution History
Within the woodlands lichen assemblage is both very sensitive to air pollution and has been subject to long term systematic recording (Rose & James, 1974, Sanderson, 2010 & NFELD, 2018). This allows the past impact of air pollution to be accessed. The data shows a considerable impact from acidifying sulphur dioxide pollution since the 19th century (Rose & James, 1974, Sanderson, 2010 & Wolseley at al, 2016). There has been a disproportional loss of lichens with blue-green bacteria as the photobiont. These include charismatic large leafy species typical of old growth woodlands in general such as *Collema*, *Leptogium*, *Lobaria*, *Fuscopannaria*, *Nephroma*, *Pannaria*, *Pseudocyphellaria* and *Sticta*. Many of these have lost or reduced to tiny and probably non-viable populations. Although the core of the New Forest was in a relatively clean area (Hawksworth & Rose, 1970), these very sensitive species were seriously still impacted. Since the latter part of the 20th century sulphur dioxide has declined massively, but to a lower proportion in relatively clean areas than in heavily polluted areas. Species that responded positively to sulphur dioxide such as the Pollution Lichen *Lecanora conizaeoides*, have declined. This species, which could be found on twigs the edges of most New Forest woods, is now completely absent from this habitat. The surviving sensitive species with blue-green bacteria, however, are not showing any obvious recovery yet. Potentially the declining level of acidifying population has still to reach suitable low levels for these very sensitive species, but further research is required to clarify this.

Past impact on other groups is poorly documented, but potentially the moss *Hylocomium splendens* may have declined in the woods in response to raised sulphur dioxide pollution.

With the decline of sulphur dioxide based pollution nitrogen based pollution has become the dominant form of air pollution impacting on epiphytic lichens (van Herk, 1999 & Wolseley, 2006).

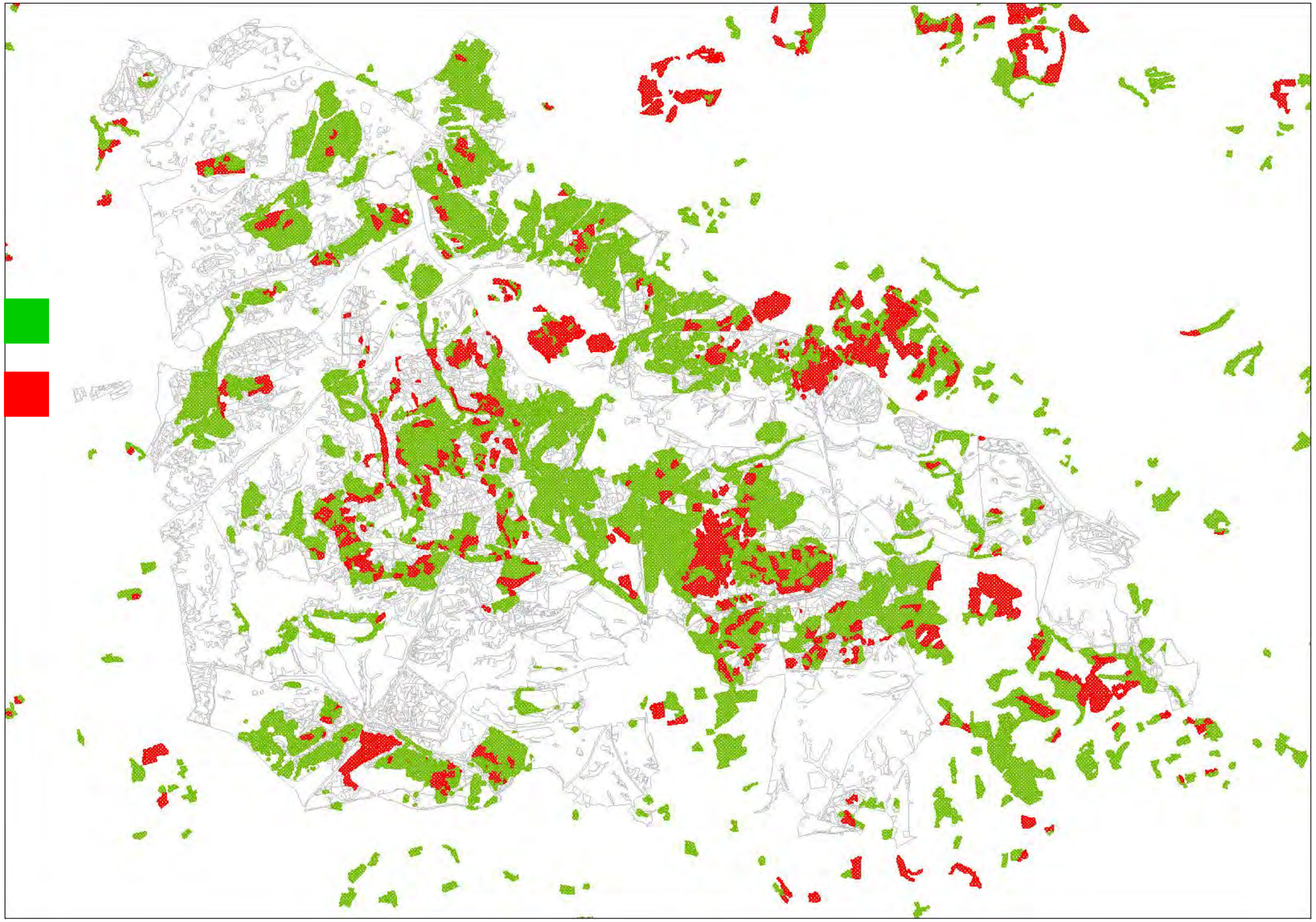
Nitrogen Based Pollution and Woodlands

Epiphytic lichens also show a strong and well defined impact to nitrogen based pollution, particularly to raised ammonia levels. Ammonia has dramatic impact on epiphytic lichens that is strong and distinctive enough to be used to map ammonia pollution levels (van Herk, 1999 & Wolseley, 2006). Frahm (2013) discuses the potential mechanism by which nitrogen deposition impacts directly on lichens. Nitrogen tolerance in lichens is hypothesised not to be based upon the higher facility for nitrogen uptake but osmotic tolerance against the salt effects of nitrogen compounds, with nitrogen intolerant species having a low osmotic tolerance. This suggests that nitrophilous species are also salt and drought tolerant species, which are preadapted to high levels of ammonium salts. Nitrogen intolerant lichens are those poorly adapted to either high salt levels or to the associated raised bark pH.

The impact of NOx or Total Nitrogen deposition are much less clear cut on epiphytic vegetation. Nitrogen oxides have a stronger acidification effects on epiphytic vegetation than they have a nitrogen enrichment effect, as lichen fungi can only metabolise nitrogen as ammonium not as nitrogen oxides (Van Herk, 1999). NOx does clearly contribute significantly to on going acidification in high rainfall areas such as in the Lake District. It may still do in the New Forest, but only to a few very sensitive species. It is very difficult to see any pattern in epiphytic lichen vegetation to Total Nitrogen deposition; conflicting impacts of eutrophication by ammonia or acidification by NOx potentially confuse any correlations.

Nitrogen impacts from aerial sources on the vascular plant and bryophyte dominated ground flora vegetation or the trees are much more difficult to observe. This is in contrast soil or surface water enrichment from arable cultivation. This can regularly observed to have made considerable changes to ground floras in ancient woodlands (Sanderson, 2008), with impacts that can last for centuries (Rackham, 1990). The changes observed in these situations are gross and involve switches in NVC communities, for example from *Quercus robur – Pteridium aquilinum – Rubus fruticosus* Woodland, typical sub-community (W10a) to *Fraxinus excelsior – Acer campestris – Mercurialis perennis* Woodland, *Hedera helix* sub-community (W8d) in Briddlesford Woods on the Isle of Wight. This had occurred where seepage from anciently cultivated arable field entered the woods (Sanderson, 2008).

A problem may be that clear gross impacts in woodland vascular plant vegetation occur at very high levels of pollution, as found in surface water pollution from arable fields. Critical levels for aerial pollution appear to be set on much more subtle impacts, which are hence very difficult to separate from various management and climatic impacts.



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3 Green Close, Woodlands, SO40 7HU
023 8029 3671

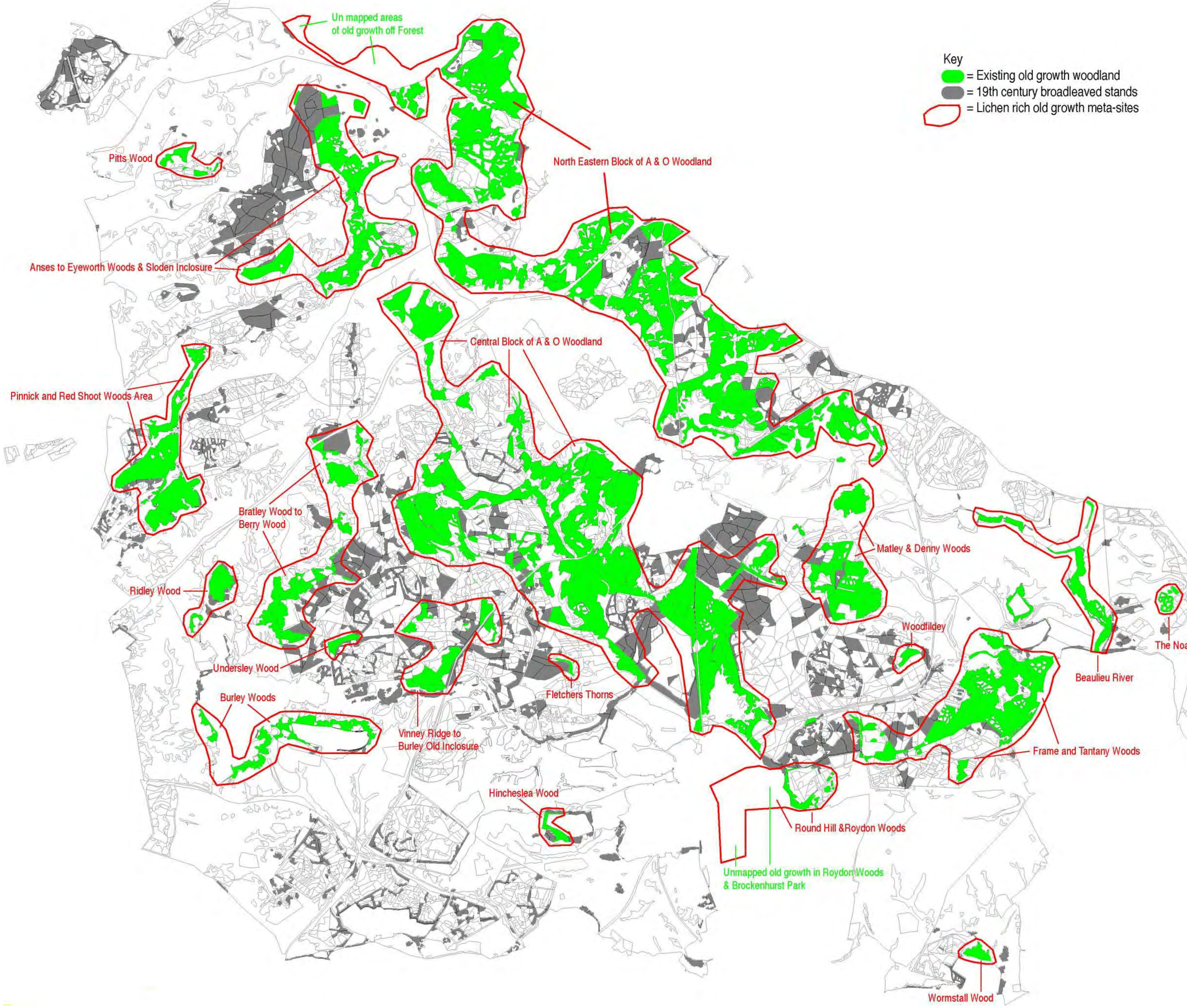
New Forest Woodland Habitats

Ancient Woodland **Map 1**

Ancient Semi-natural Woodland (both young growth and old growth and also including Oak plantations)

Conifer plantation on Ancient Woodland Sites

Sanderson (2007) based on Whyte (2004)



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New Forest Woodland Habitats

Old Growth Woodland **Map 2**

From Sanderson (2007)

New Forest SAC Woodlands

Terrestrial Vegetation
The New Forest pasture woodlands have not been subject detailed vegetation surveys or classification. Limited quadrat sampling indicated that many woodland ground floras are poor fits to the expected NVC communities Sanderson (1999). Especially on acid soils, where, in both the Beech – Oak woods and the Oak woods. bryophytes are far more prominent than in typical lowland communities. The ground floras in both were closer those of the upland *Quercus petraea – Betula pubescens – Dicranum majus* Woodland (W17) on very acid soils and *Quercus petraea – Betula pubescence – Oxalis acetosella* Woodland (W11) on mildly acid soils. The expected correspondences would be *Quercus* spp – *Betula* spp – *Deschampsia flexuosa* Woodland (W16) or *Fagus sylvatica – Deschampsia flexuosa* Woodland (W15) on strongly acid soils and *Quercus robur – Pteridium aquilinum – Rubus fruticosus* Woodland (W10) or *Fagus sylvatica – Rubus fruticosus* Woodland (W14) on mildly acidic soils. This appeared largely due to the impact of grazing, which encouraged rich bryophyte mats on acidic soils.

The Annex 1 woodland habitats listed for the New Forest SAC are listed in Table 1.

Table 1
Woodland Annex 1 Habitats Listed for the New Forest SAC

Annex 1 Habitat Code	Annex 1 Habitat Title
9120	Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrub layer (Quercion robori-petraeae or Ilici-Fagenion)
9130	Asperulo-Fagetum beech forests
9190	Old acidophilous oak woods with *Quercus robur* on sandy plains
91D0	Bog woodland
91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)

The application of the Annex 1 Habitats to a unique internationally important pasture woodland complex is not easy and some Annex 1 habitats are a poor fit for the reality of the New Forest. This is especially so for 9190 Old acidophilous Oak woods with *Quercus robur* on sandy plains. The acid Oak woodlands show limited similarities to this sub-oceanic woodland type and are generally far closer to 91A0

Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles (Sanderson, 1995). This reflects the southern oceanic climate of the New Forest and the impact of grazing. The riverine woodlands are also far more complex and interesting than implied by only listing the 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) (Sanderson, 2004a). The former are softwood riverine woodlands (Peterken & Hughes, 1995), woods of fast growing trees on wetter alluvium. In the New Forest floodplains, however, these are mosaicked with hardwood riverine woodland, which are mixed Oak woods on drier alluvium, a unique feature in Britain (Peterken, 1996). The latter appear to be an oceanic version of 91F0 Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*).

In reality it is best to regard all the old growth woodlands as Annex 1 habitats, without too much concern as to which Annex 1 habitat any particular piece of woodland might be most closely related too. In any case for most habitats the same critical loads are given:

- Nitrogen Deposition 10 kg N/ha/yr
- NOx Annual Mean 30 µg/m3
- NH_3 Annual Mean 1 µg/m^3

For nitrogen deposition this would seem likely to be a simplification; it seems very unlikely that the sensitivity of the most acid Beech stands in 9120 habitats on leached sandy soils is the same as the most base rich Beech – Sessile Oaks woods in 9130 habitats on base rich clay soils. For many habitats the NH_3 Annual Mean is described as "Site specific advice should be sought" but the annual mean of 1 µg/m^3 would clearly apply in lichen rich old growth woodland.

An exception is the 91E0 riparian woodlands, for nitrogen deposition this is described as "designated feature/feature habitat not sensitive to eutrophication". This may be true for aerial deposition but it should be noted that is habitat is actually extremely sensitive to surface water pollution. Increases on nitrogen levels within the river floodwaters would quickly push the species rich mosaic of *Fraxinus excelsior – Acer campestris – Mercurialis perennis* Woodland, *Anemone nemorosa* sub-community (W8b) and Alnus *glutinosa – Fraxinus excelsior – Lysimachia nemorosa* Woodland, *Urtica dioica* sub-community (W7a) vegetation to a uniform Nettle *Urtica dioica* species poor dominated vegetation *Alnus glutinosa – Urtica dioica* Woodland (W6).

It is very difficult to see any impact on the general vegetation from aerial pollution in the New Forest at present. If there are impacts, they are very subtle and will be exceptionally hard to untangle from management and climate influences.

Epiphytic Lichen Assemblage

The exceptionally rich epiphytic lichen assemblage is described in Rose & James, (1974) and Sanderson (2010). The assemblage is notable for the strong warm temperate oceanic element, which is a very district feature in a British context. As a result there is high proportion of lichens with *Trentepohlia* algal partners, which are deep forest species dependent on high humidity and warmth (Wolseley et al, 2016).

The assemblage is exceptionally rich in rare and threatened species. It includes five Critically Endangered, three Endangered, 10 Vulnerable, 41 Near Threatened and 75 Notable species recorded since the 1960s (NFELD, 2018, Sanderson, 2018). A total of 32 Section 41 lichens have been recorded as epiphytes since 2000 (NFELD, 2018). The extent of lichen rich meta-sites on the New Forest is shown on **Map 2** (Sanderson, 2007). These are defined as interconnected blocks of lichen rich old growth woodland not separated by more than 500m of young growth or open ground.

As discussed above the impact of past acidifying sulphur dioxide pollution is still evident in losses and declines of sensitive species. Acidification from predominately NOx but also still some sulphur dioxide may still be a depressing factor for a few very sensitive species but this is not clear.

Direct toxicity can only be easily observed and monitored for increased ammonia levels. The impact of this can readily be assessed on twigs, which give an indication of the levels of ammonia in the last few years (Wolseley et al, 2006). The monitoring is best done on trees with naturally acid bark, especially Oak. The balance between nitrophilous species and acidophilous species indicates the ammonia levels to which the twig has been exposed. The differences are visually obvious, with yellow lichens dominating in air with high ammonia levels and grey lichens dominating, including robust shrubby and long pendulous species, in the cleanest air.

The core woods of the New Forest are distant from the main sources of ammonia pollution; intensive agricultural land. The annual mean NH_3 levels are below the critical load of 1 $\mu g/m^3$ (MAP? Ammonia Concentrations from APIS) in the core of the Forest. Even where edge sites shown as slightly in exceedance, this is largely an artefact of averaging across the 5km modelling scale, most such areas are likely not to be in exceedance, but will have higher ammonia levels than the core area. This modelling is reflected in the Oak twig assemblages found across the Forest woods. Nitrophilous species are rare, while sensitive species are frequent and well grown. The especially sensitive Section 41 species *Usnea florida* is still local frequent and is widespread. Slight signs of enrichment can be seen on edge sites near agricultural land. The extensive nature of the low intensity land use in the Forest is providing a very effective buffer to ammonia pollution.

NOx levels are well below the critical level and impacts are not clear. The most significant impact on epiphytic lichens is likely to be increased bark acidity. Observations of differential absence of base demanding old growth dependent lichens within Hollands Wood campsite, compared to adjacent woodland, is potentially the result of NOx pollution. The source would be the many cold started cars parked within this woodland cap site (Edwards, 2001 & Sanderson, 2004b). Other lower pH lichens habitats still supported rich assemblages, including Red Data Book species at a similar level to woodland close to the campsite.

Total Nitrogen deposition does not clearly relate any single impact on epiphytic lichens, ether locally or nationally.

Current direct road impact on lichens have be been looked at systematically. Trunks immediately adjacent to busy roads, however, have been noted as being species poor. This appears to be largely due to physical deposition of road dust and as an obvious visual impact drops off very quickly away from the road.

Modelled Road Impacts

Lichen Rich Areas with Potential Impact
The areas with modelled exceedance by 2036 resulting from the local plan are quite limited but do overlap with the SAC and include areas in lichen rich old growth woodland. The exceedance by ammonia is most widespread but with NOx exceedance showing a similar pattern if in in more limited areas. The areas where modelled exceedance by ammonia and lichen rich old growth woodlands occur are listed below.

The largest exceedance is modelled for:

- A337 Lyndhurst to Cadnam: this includes known important lichen rich areas within 200m of the road in the Shave Wood and French's Bushes (NF14) complex and Rockram Wood (NF13) (NFELD, 2018).

Lower exceedances are modelled for:

- A35 Ashurst to Lyndhurst: this includes a sizable strip of lichen rich woodland at Mallard Wood (NF41) and a small area of Rushpole Wood (NF13) within 200m of the road (NFELD, 2018).

- A337 Lyndhurst to Brockenhurst: this includes known important lichen rich areas within 200m of the road in the Hollands Wood (NF27) complex and Whitley Wood (NF13) (NFELD, 2018).

- A35 Lyndhurst to Markway Bridge: this includes areas of lichen rich woodland at Lyndhurst Hill to Warwick Slade and Brinken Wood (NF20, 21 & NF19A) within 200m of the road along with patches at Vinney Ridge (NF01) and Burley Old Inclosure (NF31) (NFELD, 2018).

Monitoring
Monitoring for ammonia impact along and in from the roads would be straight forward using an adaption of the twig monitoring method described in Wolseley et al (2006).

Mitigation
Mitigating ammonia impact is possible (refs?) as dense tall vegetation can rapidly scrub out excess emissions. For example open land between sensitive habitat and a point source can be planted with new woodland. The scope for doing this in the New Forest SAC, however, is very limited as any potential problems are where roads cut directly through rich habitats. Any effective mitigation measures would be likely to damage the SAC habitat even more than the potential damage from pollution exceedance.

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Appendix 4

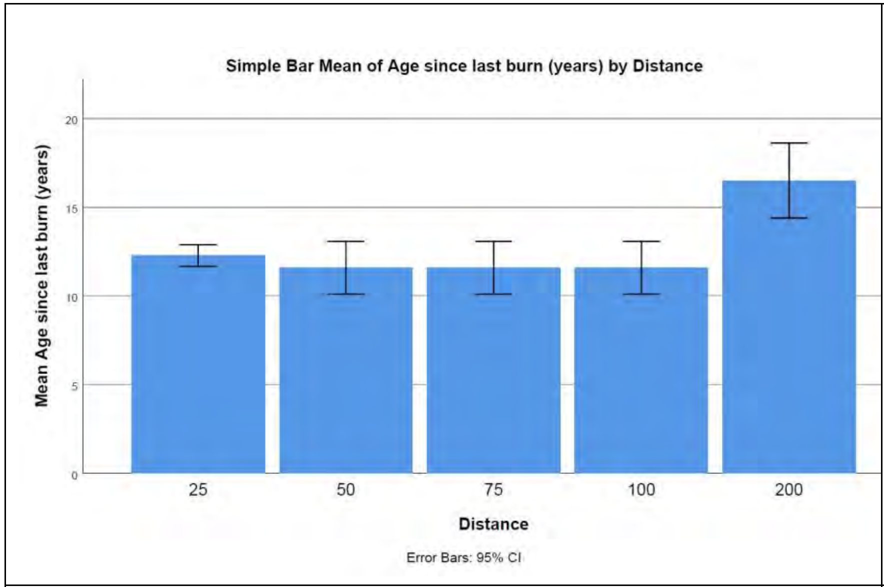
Summary of Species List Recorded in the Survey Area

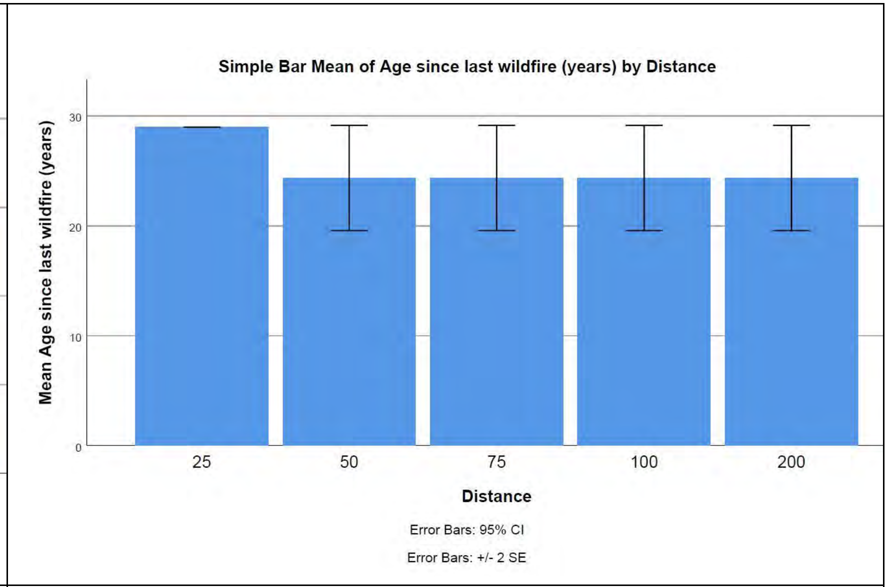
Species name	No. Quadrats Present	Species name	No. Quadrats Present
Achillea millefolium	1	*Pedicularis sylvatica*	1
Agostis canina	1	*Pilosella officinalis*	1
Agrostis capillaris	22	*Poa sp.*	3
Agrostis curtisii	91	*Polygala sepyllifolia*	87
Aira praecox	6	*Polytrichum formosum*	17
Calluna vulgaris	151	*Polytrichum juniperinum*	12
Campylopus introflexus	95	*Potentilla erecta*	16
Carex binervis	6	*Prunella vulgaris*	1
Carex demissa	1	*Pseudoscleropodium purum*	3
Carex flacca	1	*Pteridium aquilinum*	15
Carex panicea	16	*Riccia sp.*	1
Carex pilulifera	58	*Rubus fruticosus agg.*	11
Cephalozia connivens	1	*Rumex acetosella*	2
Cladonia portentosa	40	*Taraxacum*	1
Cladonia spp.	35	*Teucrium scorodonia*	1
Danthonia decumbens	20	*Trichophorum germanicum*	6
Dicranum scoparium	11	*Ulex europaeus adult*	1
Erica cinerea	38	*Ulex europaeus seedling*	33
Erica tetralix	105	*Ulex minor*	43
Galium saxatile	15	*Veronica officinalis*	5
Hieracium agg.	6	*Viola riviniana*	2
Hypnum jutlandicum	118		
Hypnum lacunosum	3		
Hypochaeris radicata	12		
Juncus bufonius	2		
Leontodon saxatilis	1		
Leucobryum glaucum	16		
Luzula campestris	5		
Luzula multiflora	1		
Molinia caerulea	150		

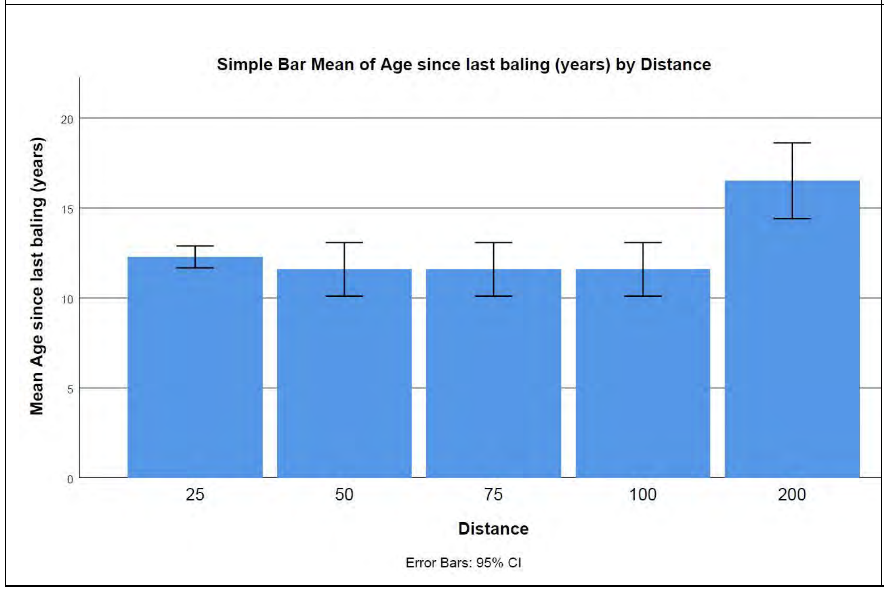
Appendix 5

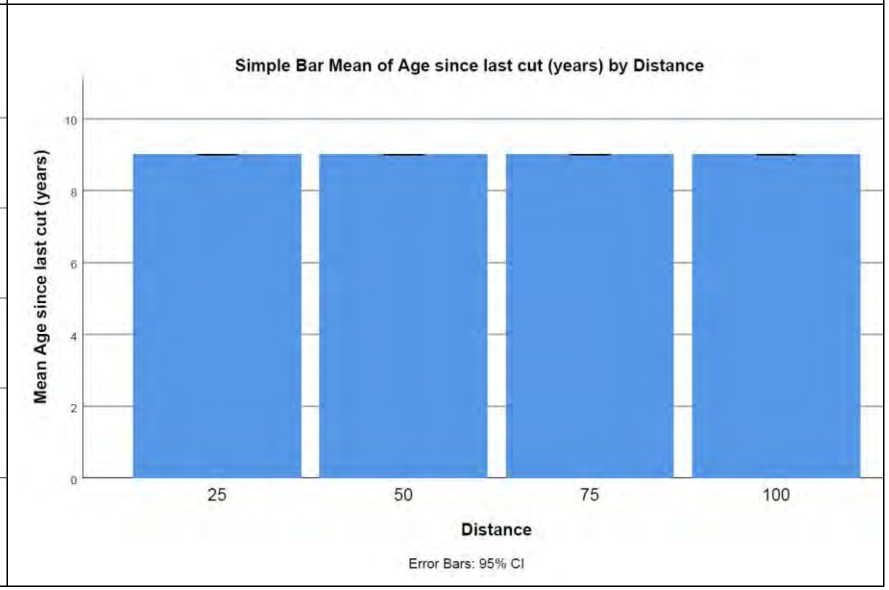
Graphical Analysis of A31 Transect Results

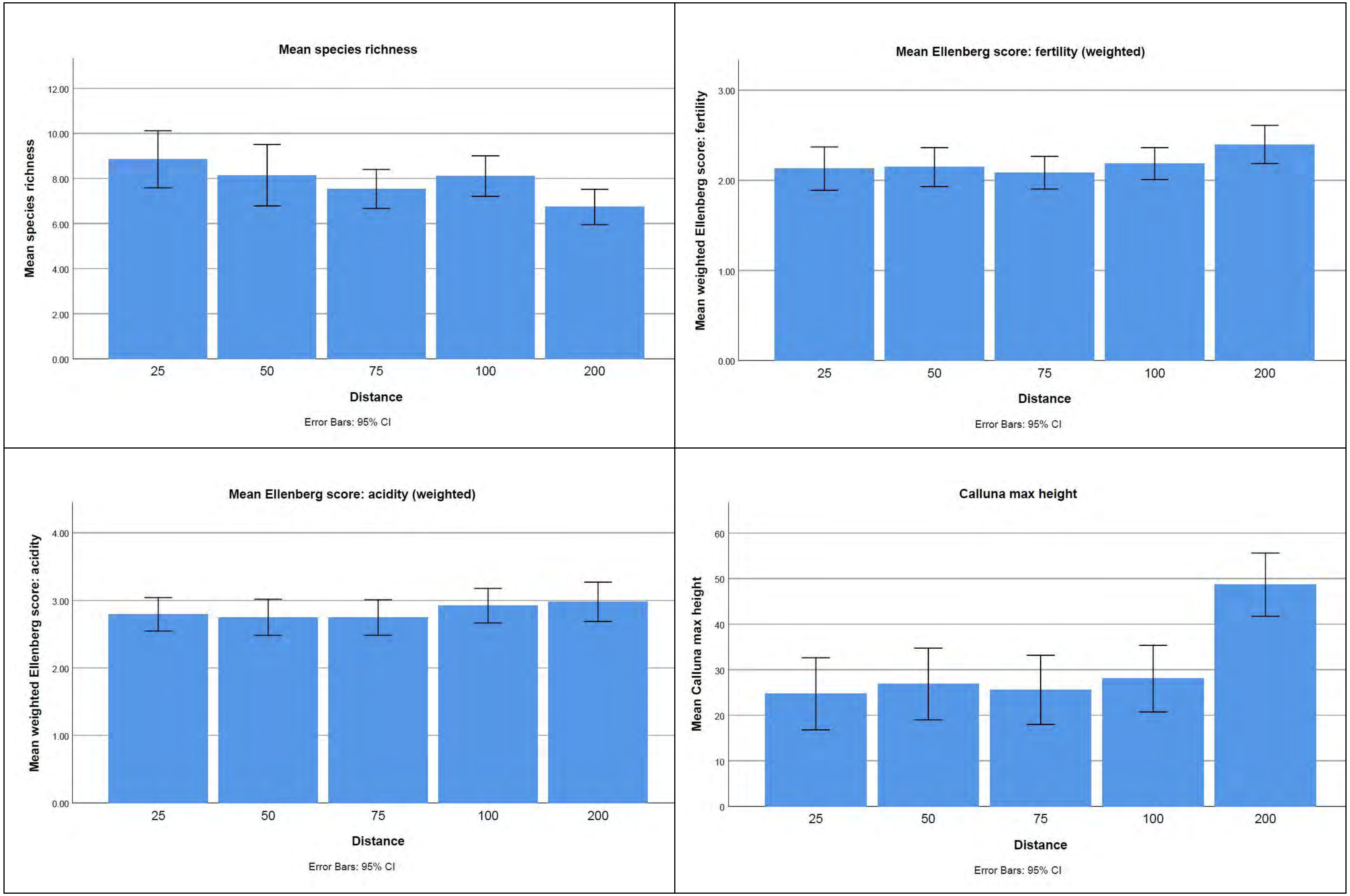
N.B. Unless otherwise stated, the Y-axis represents mean percentage cover and the X-axis mean distance (m) from road edge


Simple Bar Mean of Age since last burn (years) by Distance
Mean Age since last burn (years)
0
5
10
15
20
25
50
75
100
200
Distance
Error Bars: 95% CI

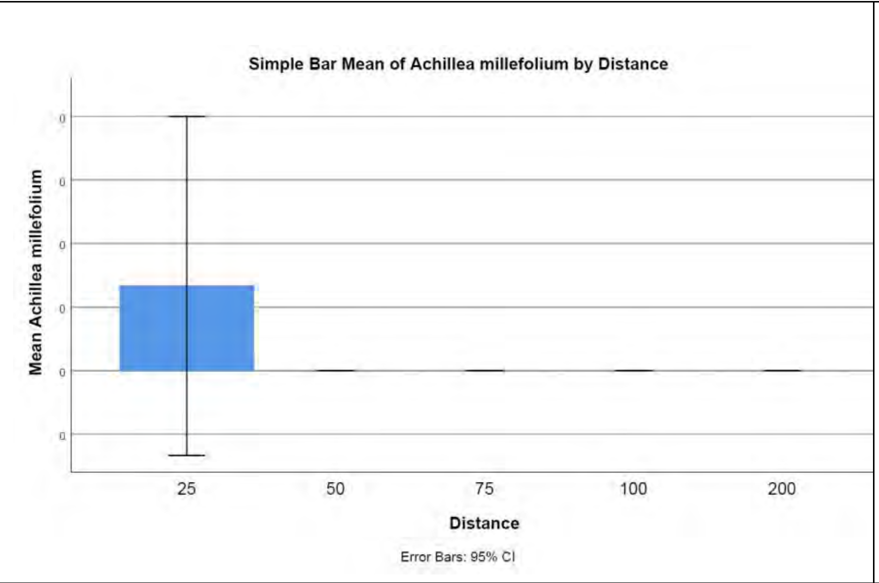

Simple Bar Mean of Age since last wildfire (years) by Distance
Mean Age since last wildfire (years)
0
10
20
30
25
50
75
100
200
Distance
Error Bars: 95% CI
Error Bars: +/- 2 SE


Simple Bar Mean of Age since last baling (years) by Distance
Mean Age since last baling (years)
0
5
10
15
20
25
50
75
100
200
Distance
Error Bars: 95% CI

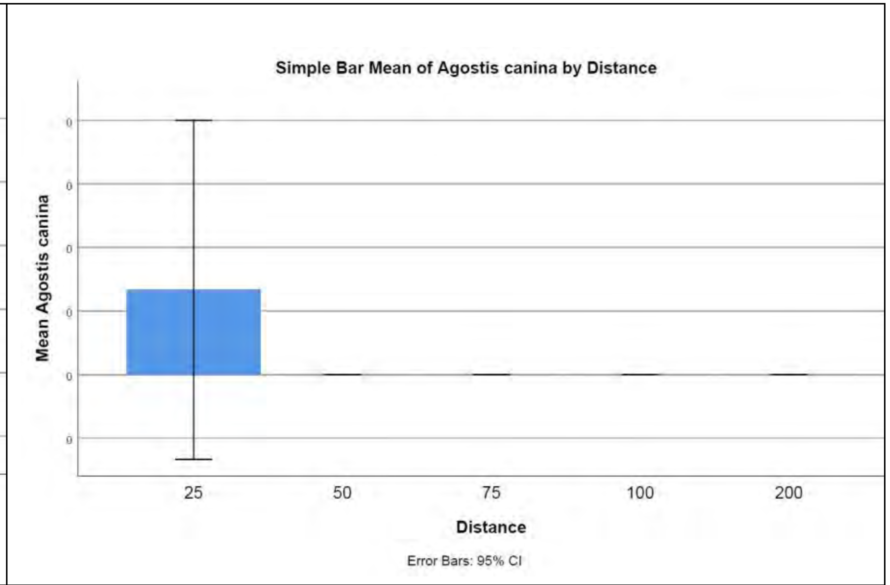

Simple Bar Mean of Age since last cut (years) by Distance
Mean Age since last cut (years)
0
2
4
6
8
10
25
50
75
100
Distance
Error Bars: 95% CI



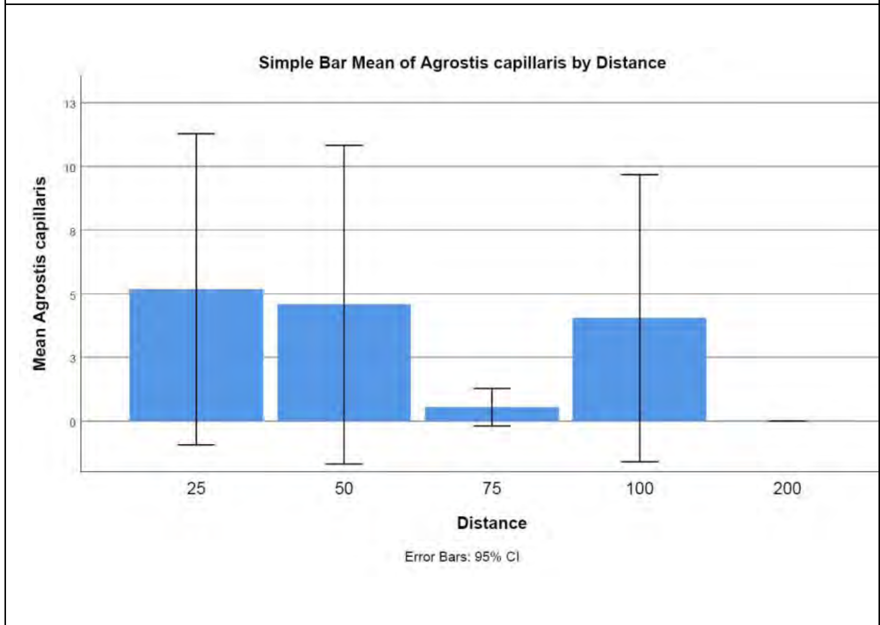
Mean species richness
Mean species richness
12.00
10.00
8.00
6.00
4.00
2.00
0.00
25
50
75
100
200
Distance
Error Bars: 95% CI
Mean Ellenberg score: fertility (weighted)
Mean weighted Ellenberg score: fertility
3.00
2.00
1.00
0.00
25
50
75
100
200
Distance
Error Bars: 95% CI
Mean Ellenberg score: acidity (weighted)
Mean weighted Ellenberg score: acidity
4.00
3.00
2.00
1.00
0.00
25
50
75
100
200
Distance
Error Bars: 95% CI
Calluna max height
Mean Calluna max height
60
50
40
30
20
10
0
25
50
75
100
200
Distance
Error Bars: 95% CI



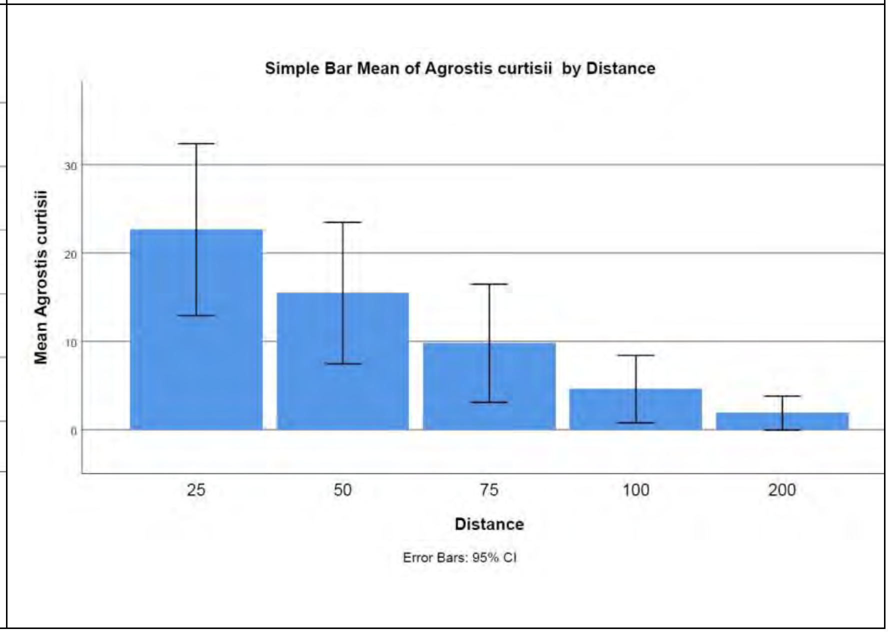
Simple Bar Mean of Achillea millefolium by Distance
Mean Achillea millefolium
25
50
75
100
200
Distance
Error Bars: 95% CI



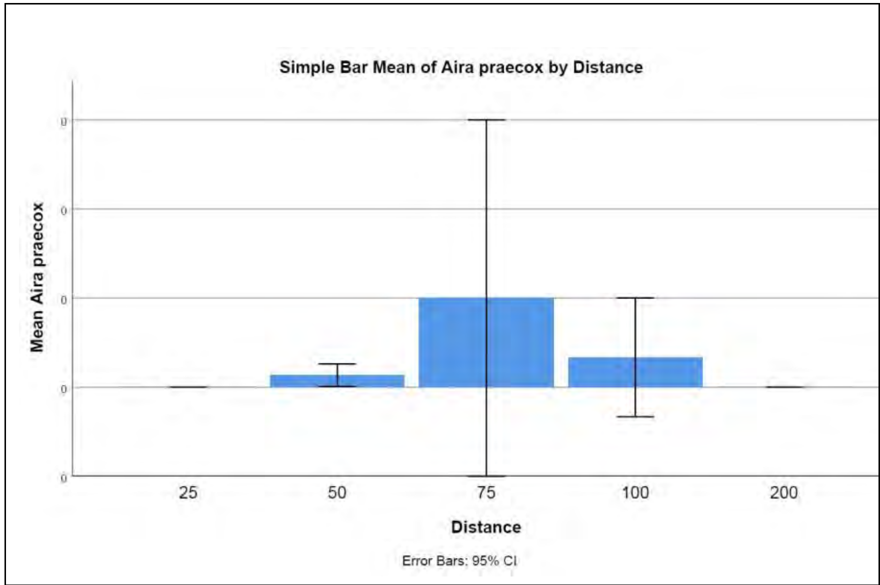
Simple Bar Mean of Agostis canina by Distance
Mean Agostis canina
25
50
75
100
200
Distance
Error Bars: 95% CI

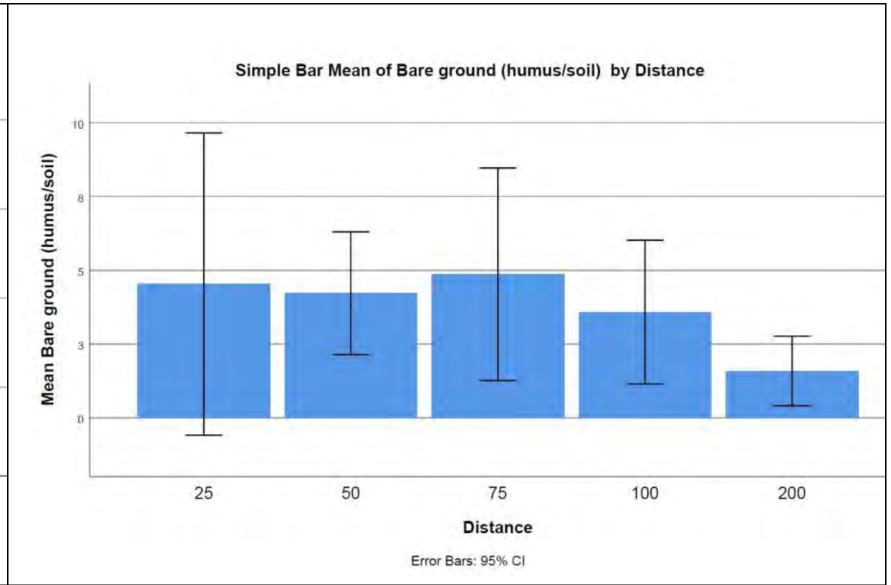


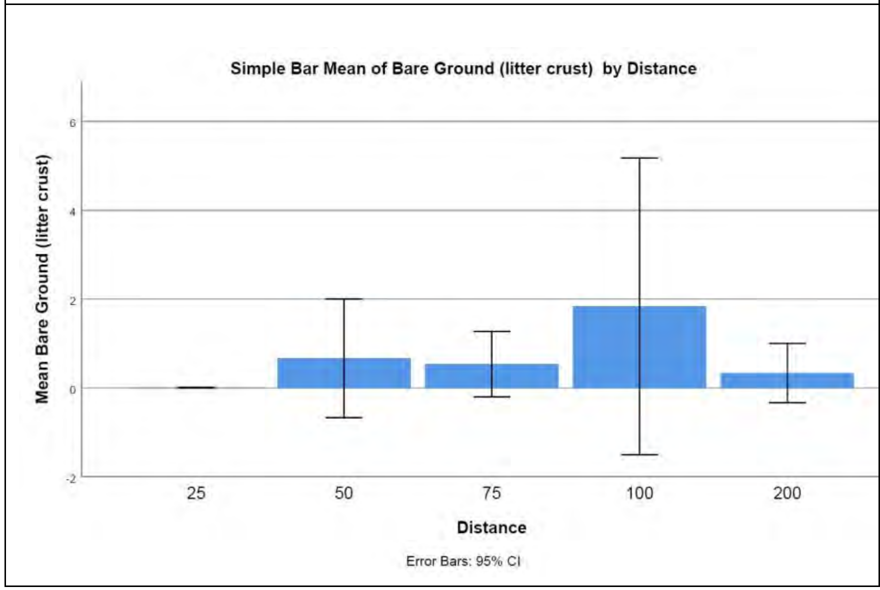
Simple Bar Mean of Agrostis capillaris by Distance
Mean Agrostis capillaris
25
50
75
100
200
Distance
Error Bars: 95% CI

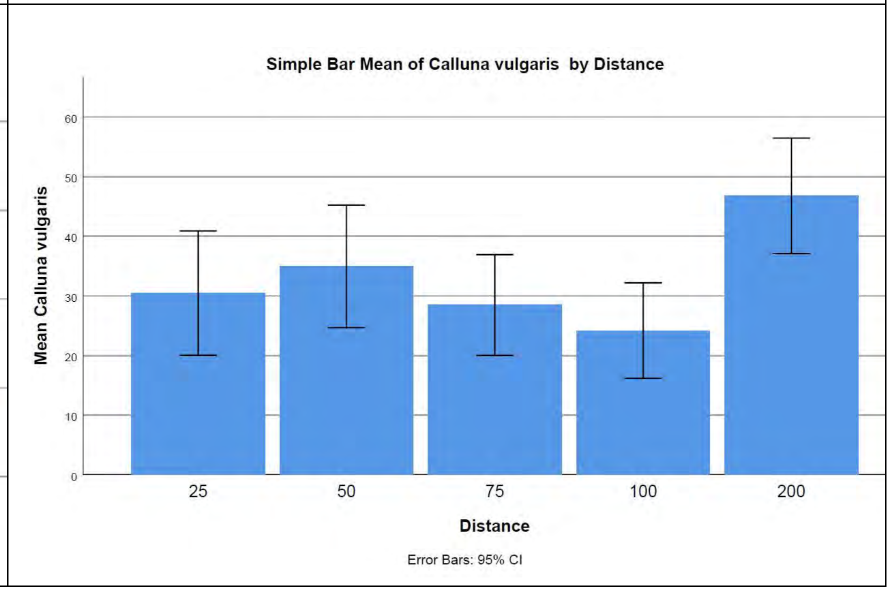


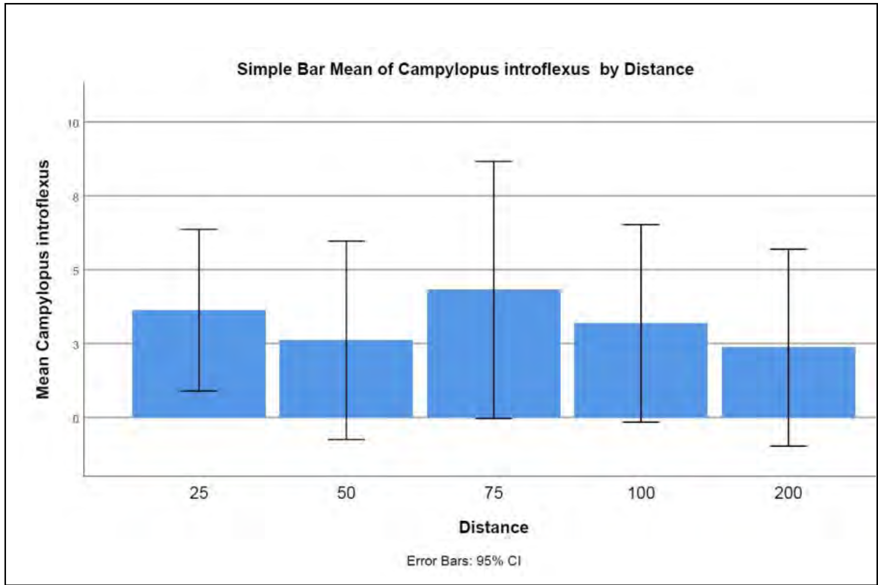
Simple Bar Mean of Agrostis curtisii by Distance
Mean Agrostis curtisii
30
20
10
0
25
50
75
100
200
Distance
Error Bars: 95% CI

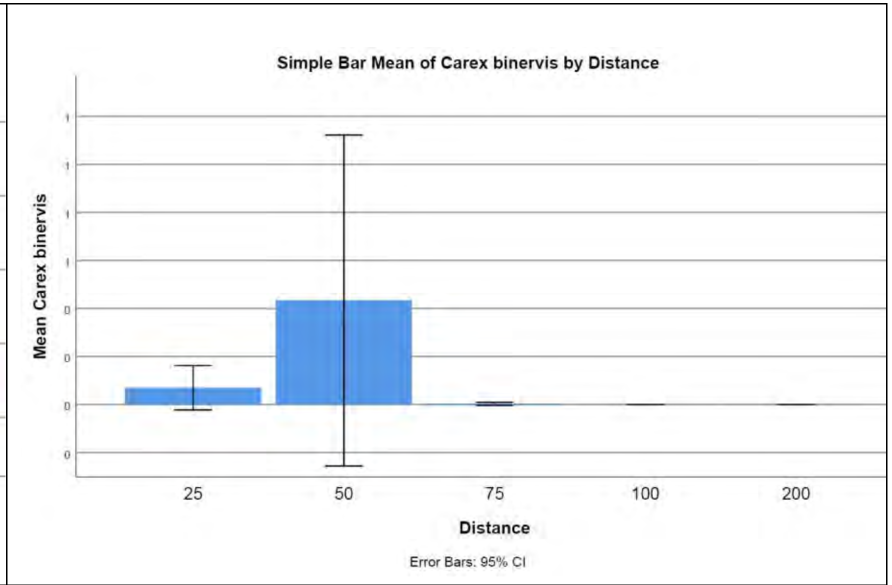

Simple Bar Mean of Aira praecox by Distance
Mean Aira praecox
0
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

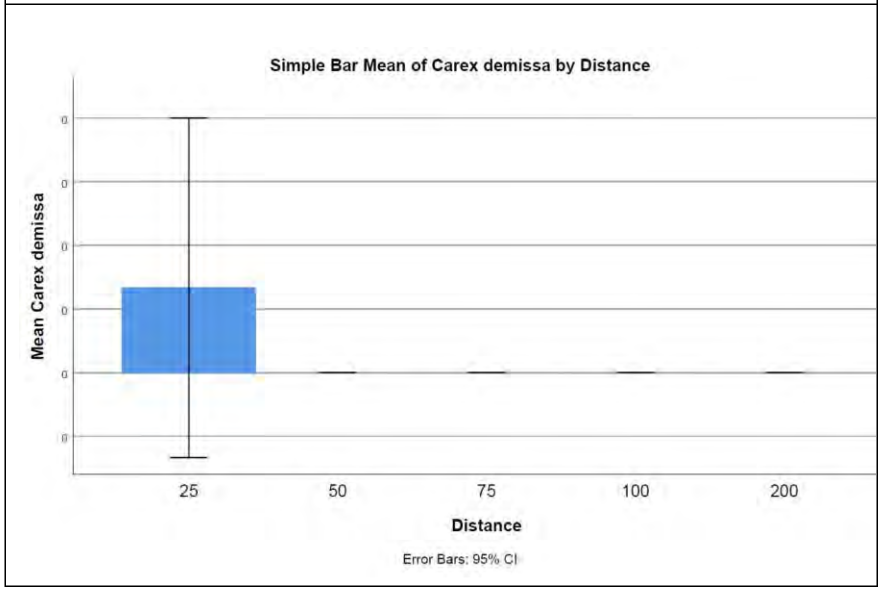

Simple Bar Mean of Bare ground (humus/soil) by Distance
Mean Bare ground (humus/soil)
10
8
5
3
0
25
50
75
100
200
Distance
Error Bars: 95% CI

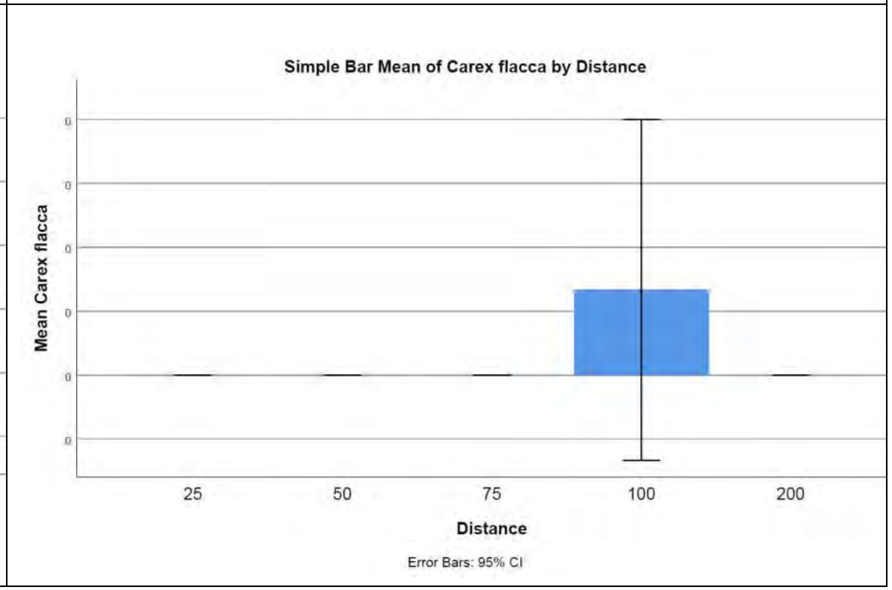

Simple Bar Mean of Bare Ground (litter crust) by Distance
Mean Bare Ground (litter crust)
6
4
2
0
-2
25
50
75
100
200
Distance
Error Bars: 95% CI

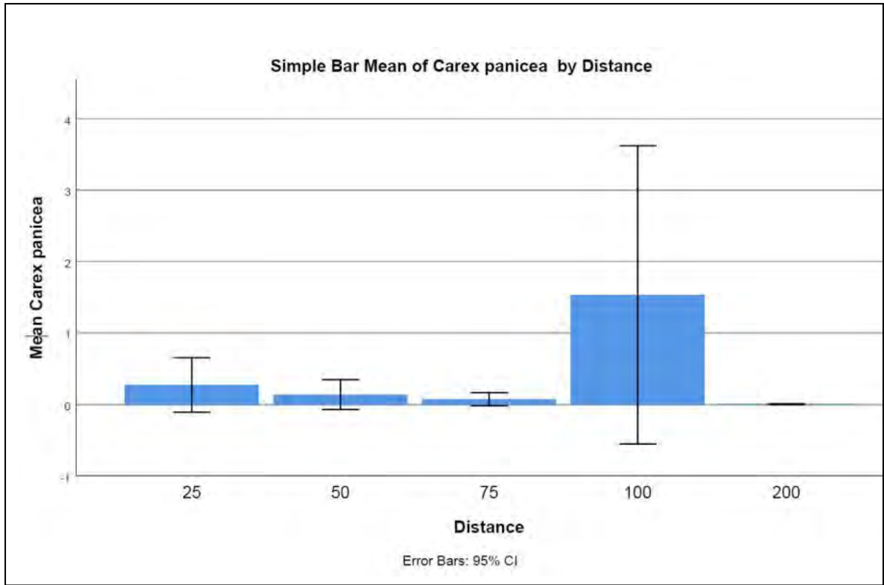

Simple Bar Mean of Calluna vulgaris by Distance
Mean Calluna vulgaris
60
50
40
30
20
10
0
25
50
75
100
200
Distance
Error Bars: 95% CI

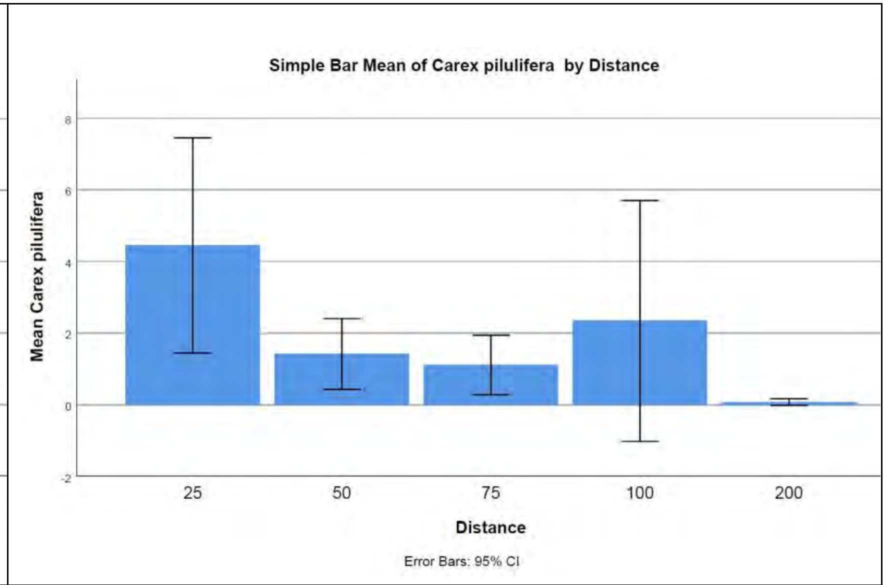

Simple Bar Mean of Campylopus introflexus by Distance
Mean Campylopus introflexus
10
8
5
3
0
25
50
75
100
200
Distance
Error Bars: 95% CI

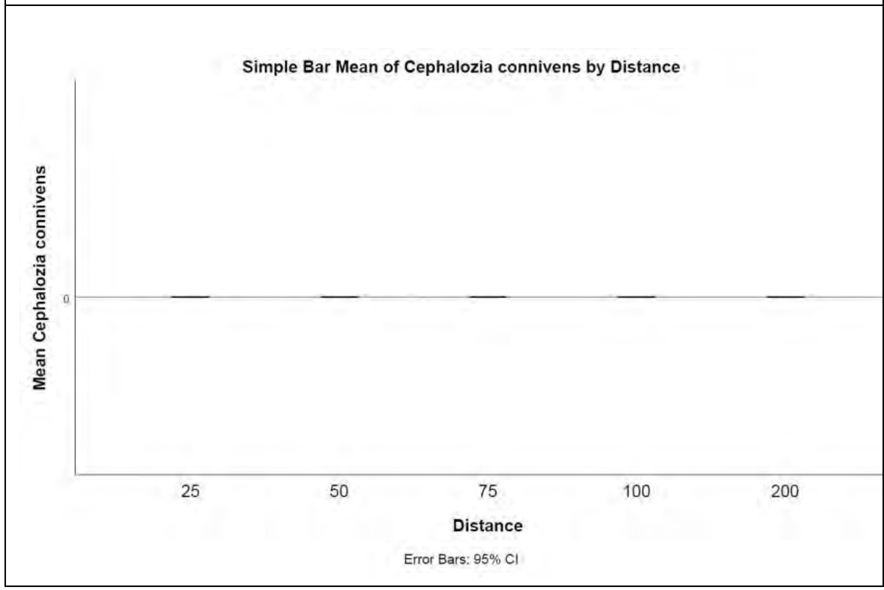

Simple Bar Mean of Carex binervis by Distance
Mean Carex binervis
25
50
75
100
200
Distance
Error Bars: 95% CI

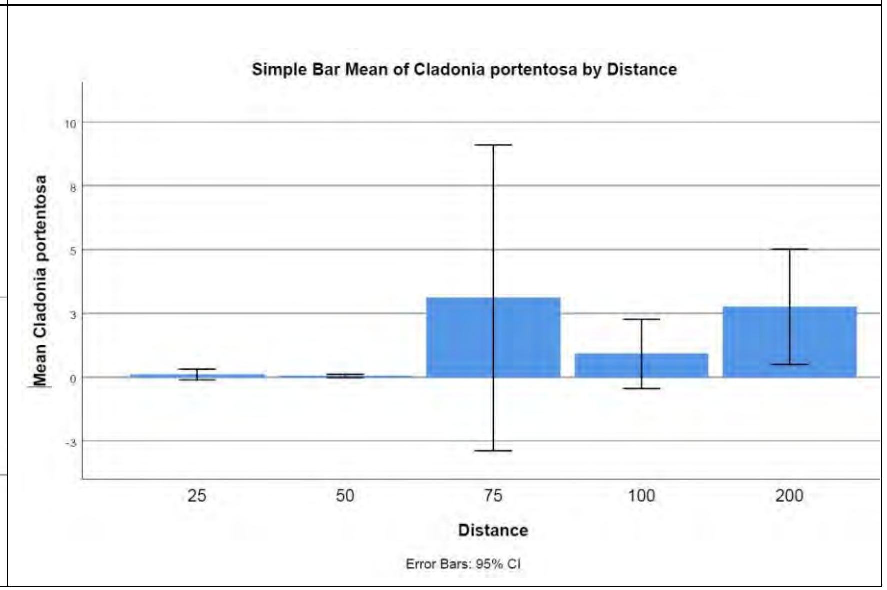

Simple Bar Mean of Carex demissa by Distance
Mean Carex demissa
25
50
75
100
200
Distance
Error Bars: 95% CI

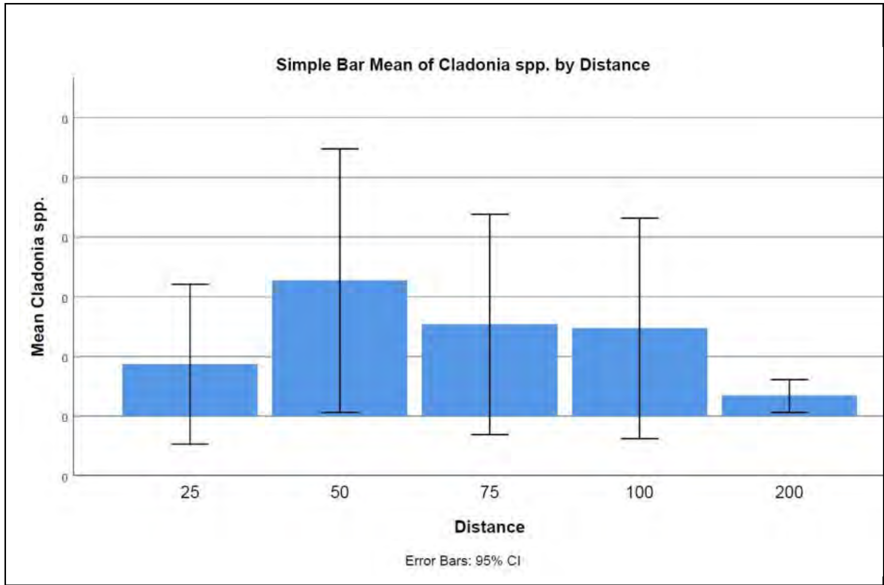

Simple Bar Mean of Carex flacca by Distance
Mean Carex flacca
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Carex panicea by Distance
Mean Carex panicea
4
3
2
1
0
-1
25
50
75
100
200
Distance
Error Bars: 95% CI

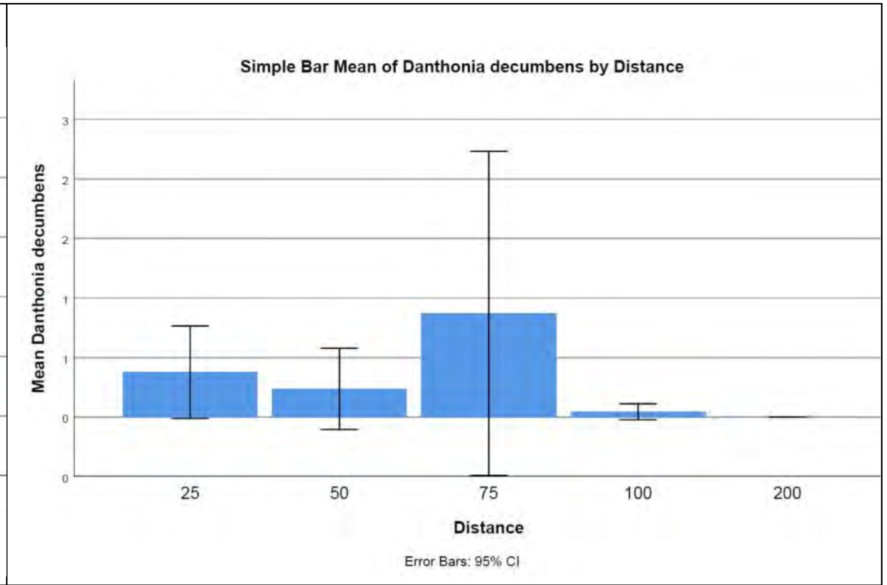

Simple Bar Mean of Carex pilulifera by Distance
Mean Carex pilulifera
8
6
4
2
0
-2
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Cephalozia connivens by Distance
Mean Cephalozia connivens
0
25
50
75
100
200
Distance
Error Bars: 95% CI

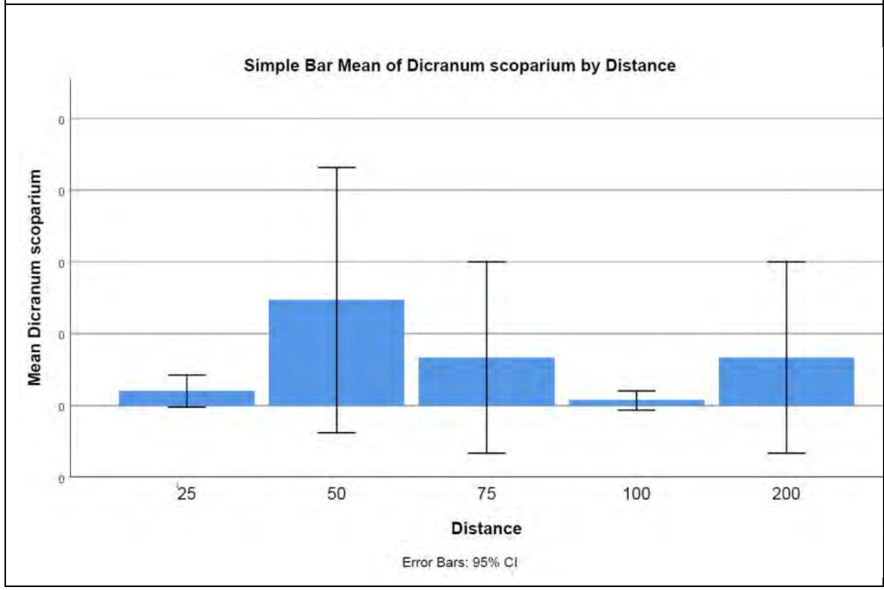

Simple Bar Mean of Cladonia portentosa by Distance
Mean Cladonia portentosa
10
8
5
3
0
-3
25
50
75
100
200
Distance
Error Bars: 95% CI



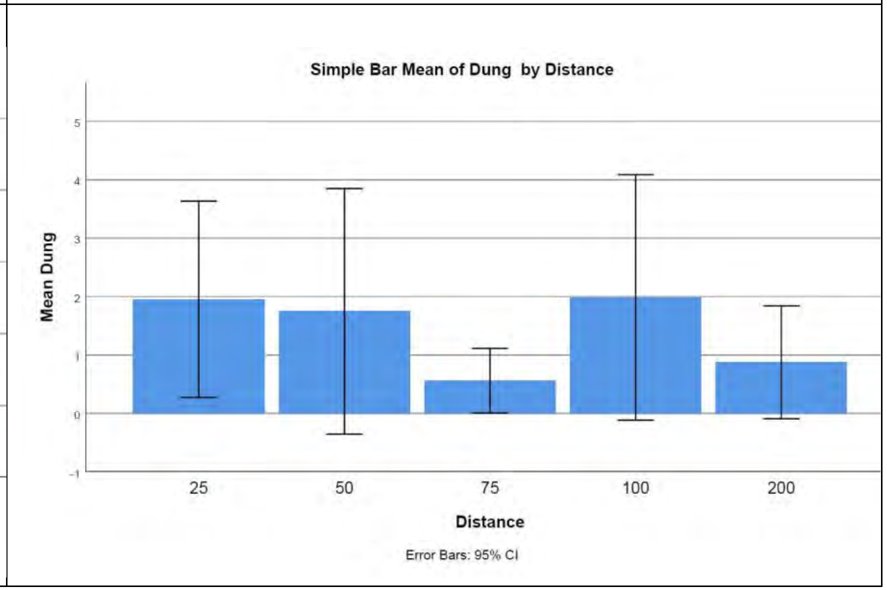
Simple Bar Mean of Cladonia spp. by Distance
Mean Cladonia spp.
25
50
75
100
200
Distance
Error Bars: 95% CI



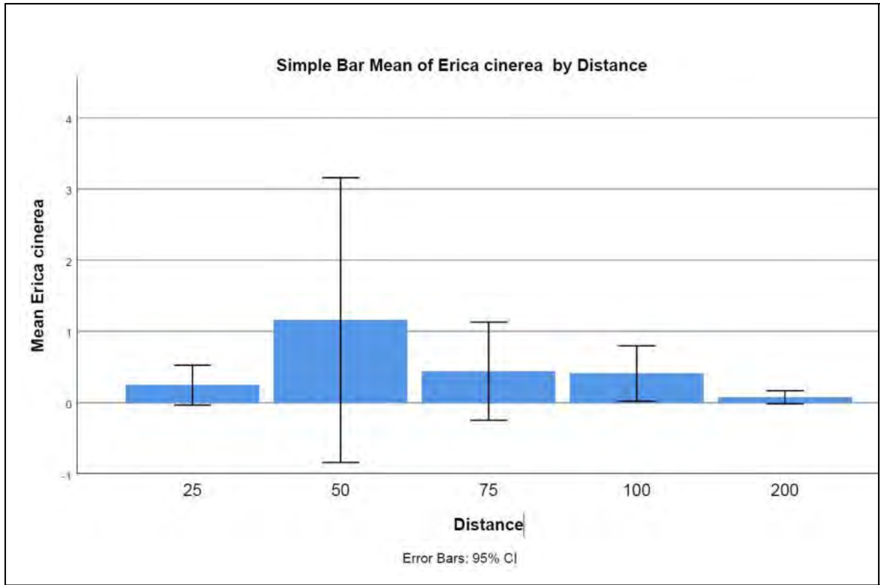
Simple Bar Mean of Danthonia decumbens by Distance
Mean Danthonia decumbens
25
50
75
100
200
Distance
Error Bars: 95% CI

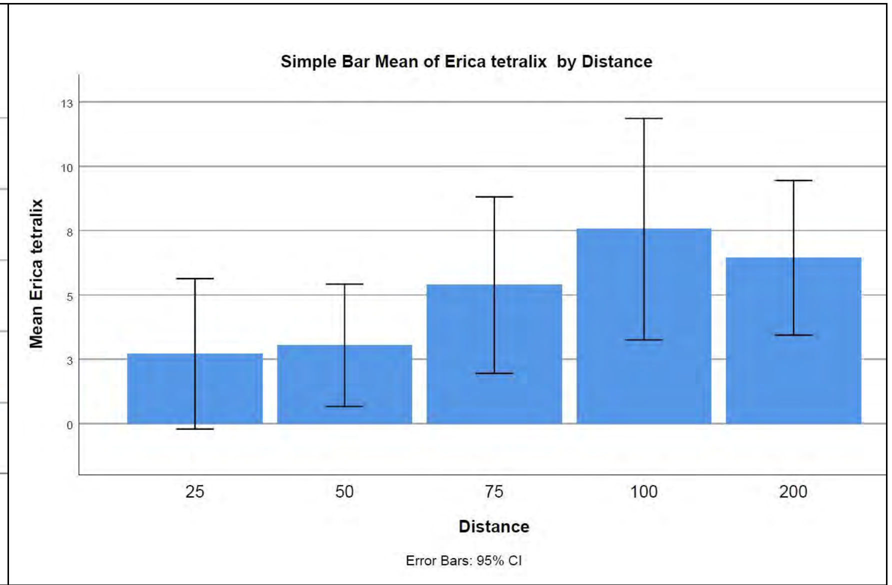


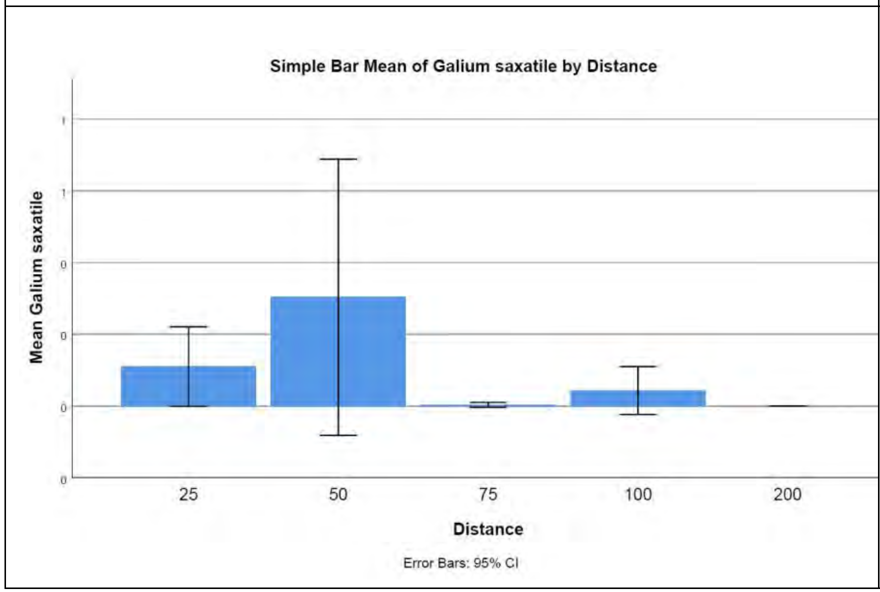
Simple Bar Mean of Dicranum scoparium by Distance
Mean Dicranum scoparium
25
50
75
100
200
Distance
Error Bars: 95% CI

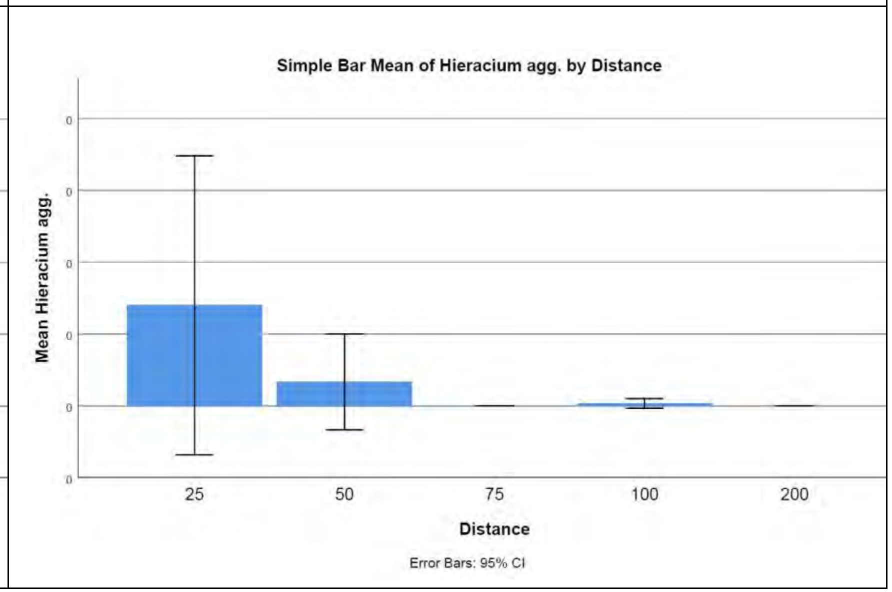


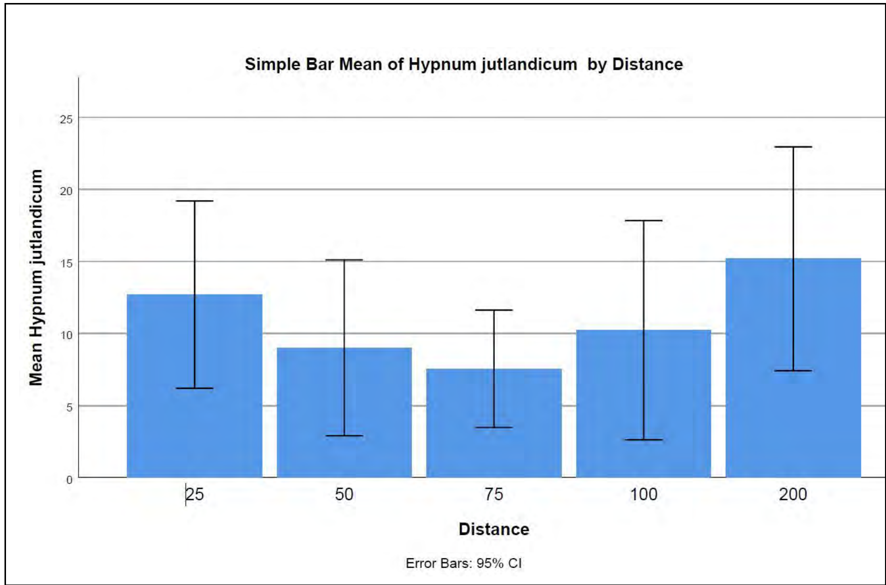
Simple Bar Mean of Dung by Distance
Mean Dung
5
4
3
2
1
0
-1
25
50
75
100
200
Distance
Error Bars: 95% CI

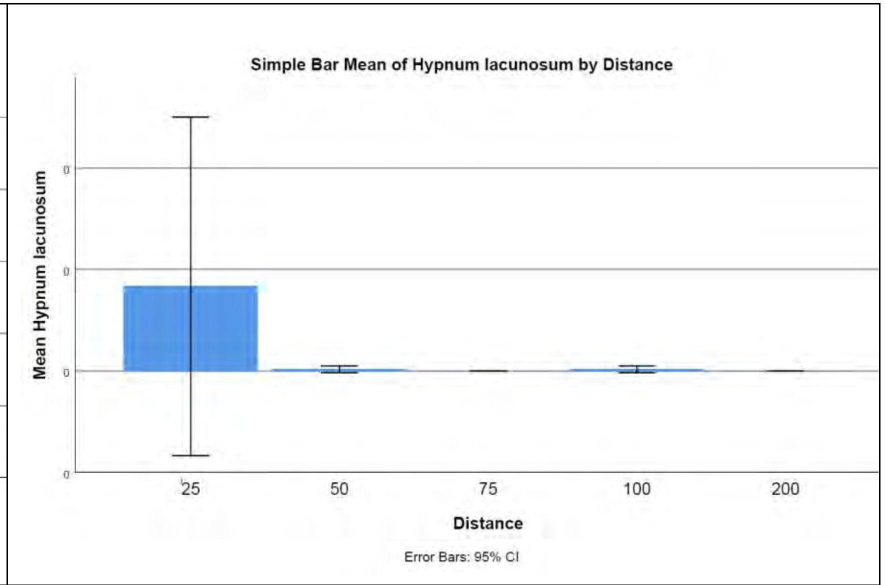

Simple Bar Mean of Erica cinerea by Distance
Mean Erica cinerea
4
3
2
1
0
-1
25
50
75
100
200
Distance
Error Bars: 95% CI

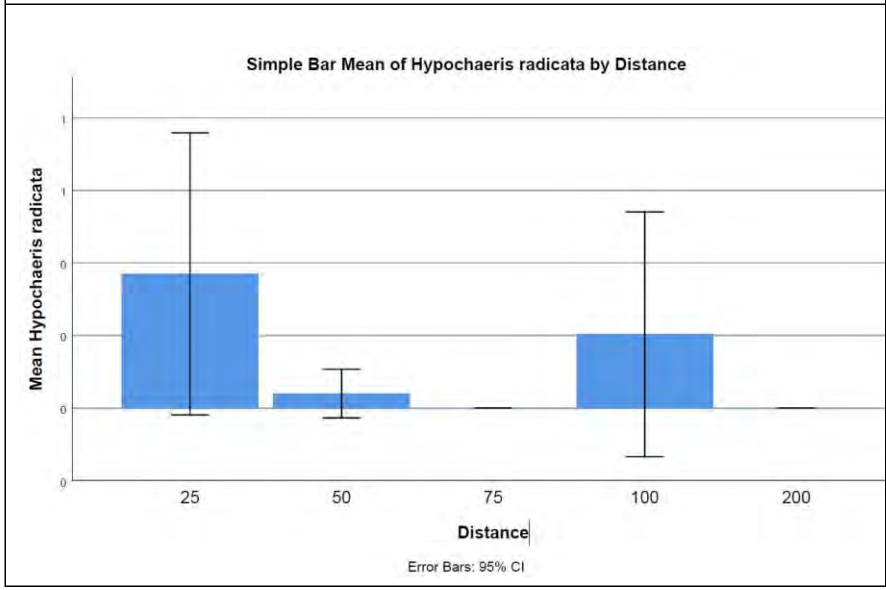

Simple Bar Mean of Erica tetralix by Distance
Mean Erica tetralix
13
10
8
5
3
0
25
50
75
100
200
Distance
Error Bars: 95% CI

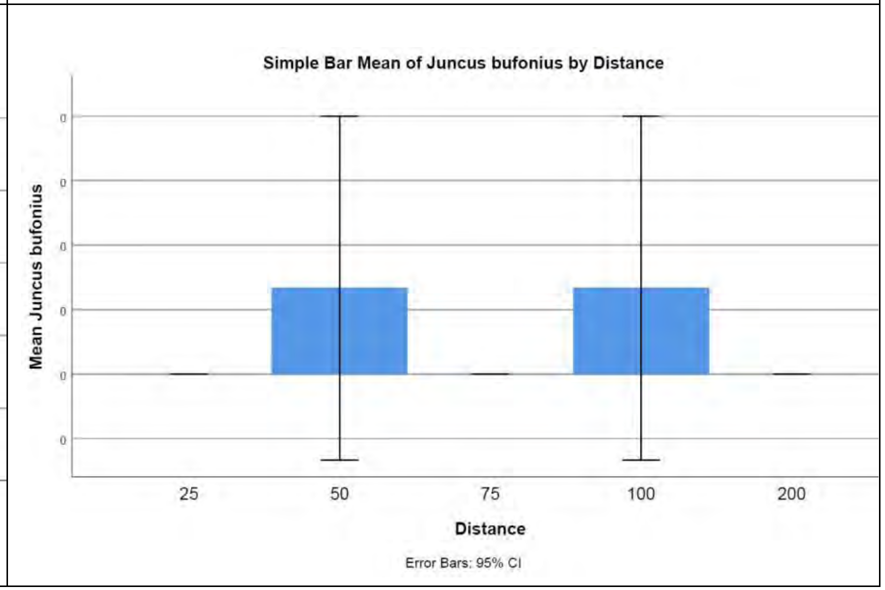

Simple Bar Mean of Galium saxatile by Distance
Mean Galium saxatile
25
50
75
100
200
Distance
Error Bars: 95% CI

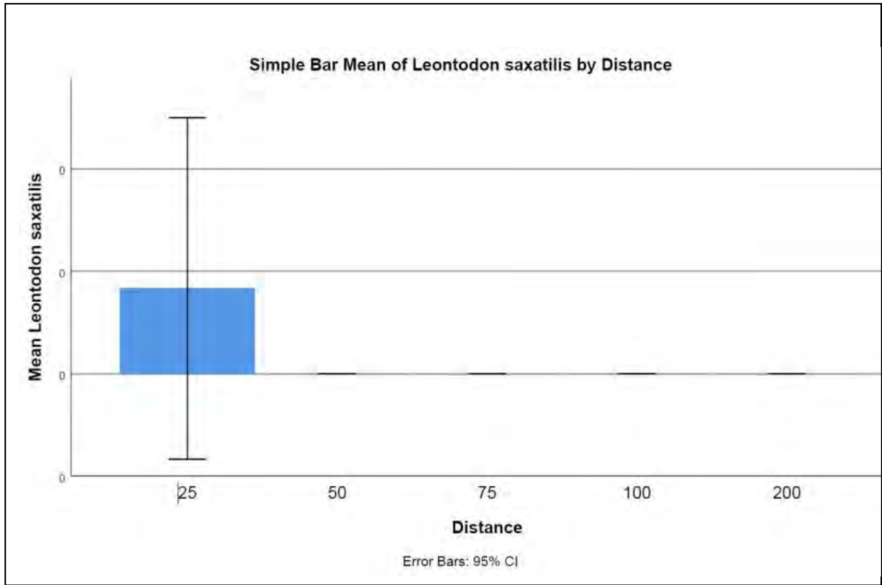

Simple Bar Mean of Hieracium agg. by Distance
Mean Hieracium agg.
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Hypnum jutlandicum by Distance
Mean Hypnum jutlandicum
25
20
15
10
5
0
25
50
75
100
200
Distance
Error Bars: 95% CI

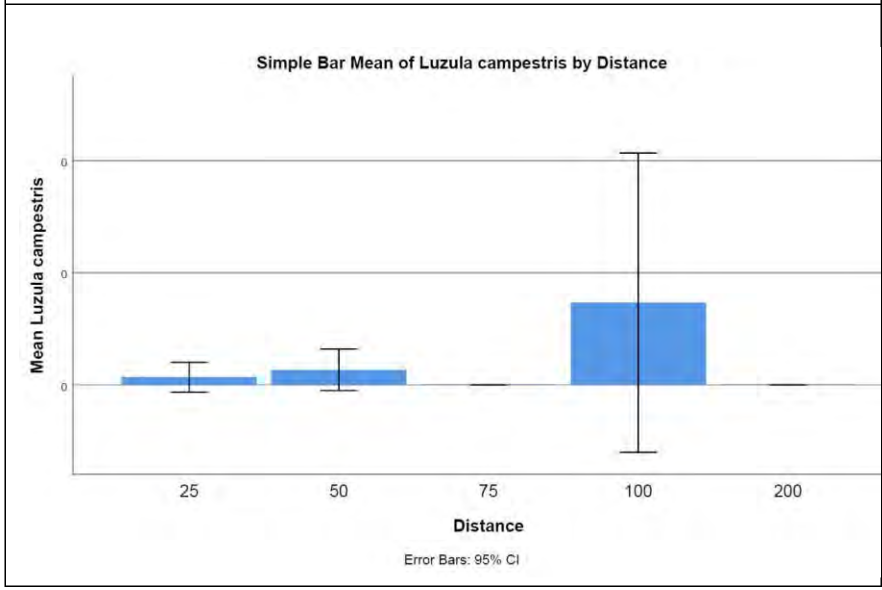

Simple Bar Mean of Hypnum lacunosum by Distance
Mean Hypnum lacunosum
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

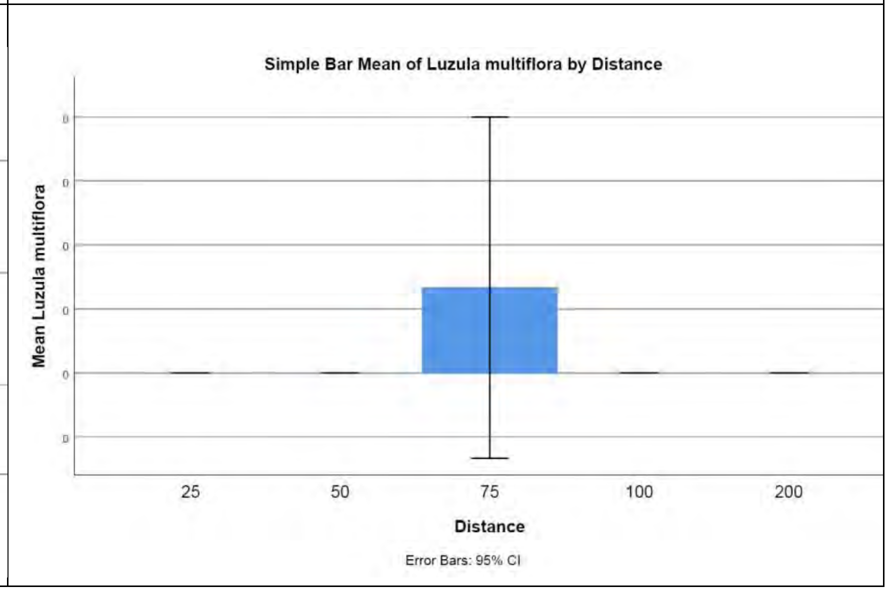

Simple Bar Mean of Hypochaeris radicata by Distance
Mean Hypochaeris radicata
1
1
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

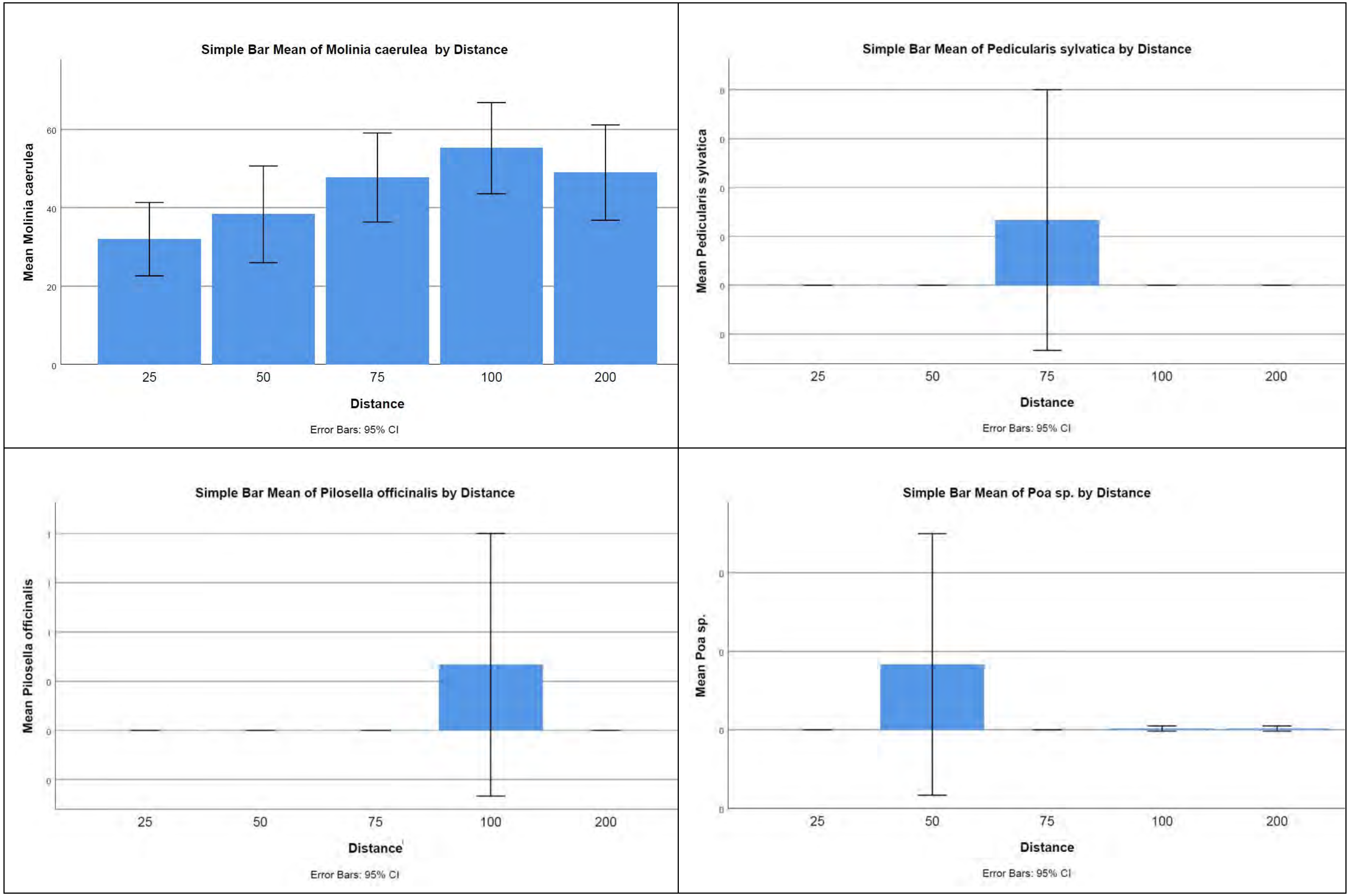

Simple Bar Mean of Juncus bufonius by Distance
Mean Juncus bufonius
0
0
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Leontodon saxatilis by Distance
Mean Leontodon saxatilis
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

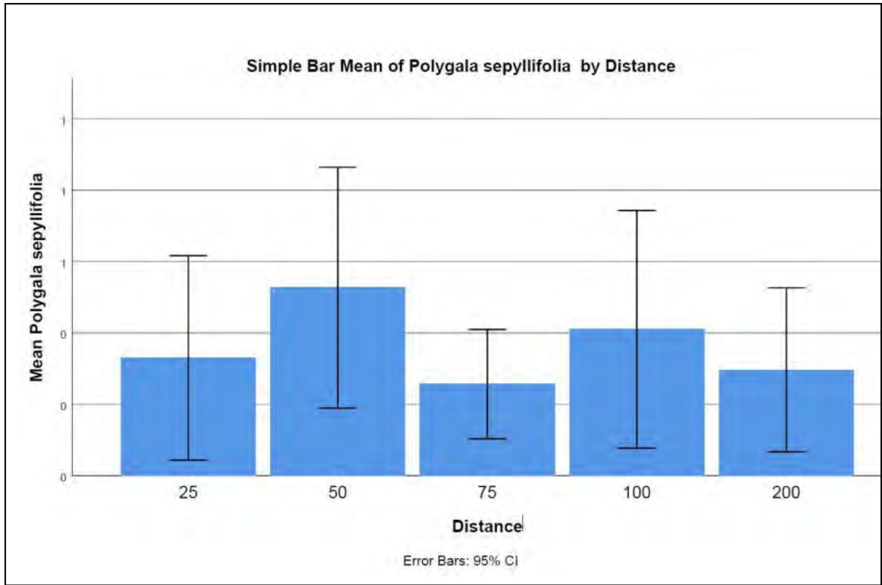

Simple Bar Mean of Leucobryum glaucum by Distance
Mean Leucobryum glaucum
3
2
1
0
-1
25
50
75
100
200
Distance
Error Bars: 95% CI

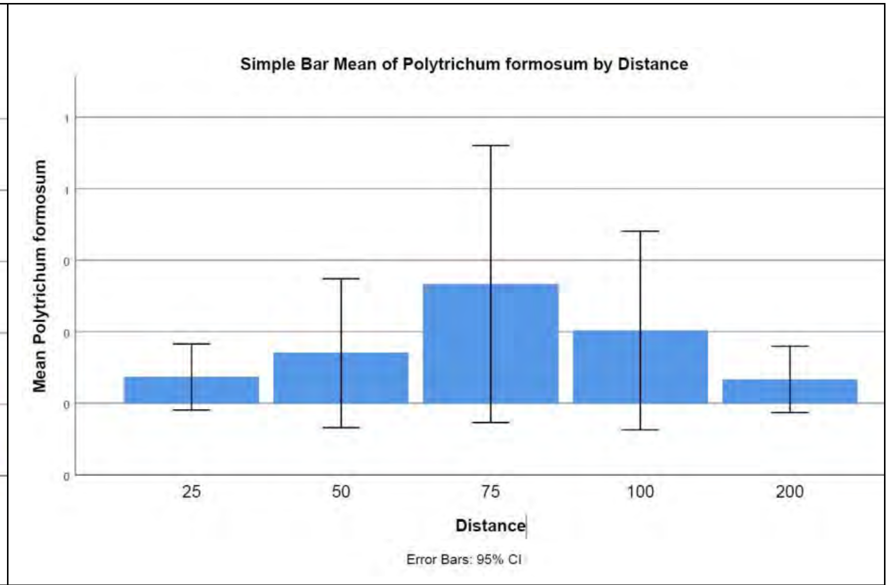

Simple Bar Mean of Luzula campestris by Distance
Mean Luzula campestris
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

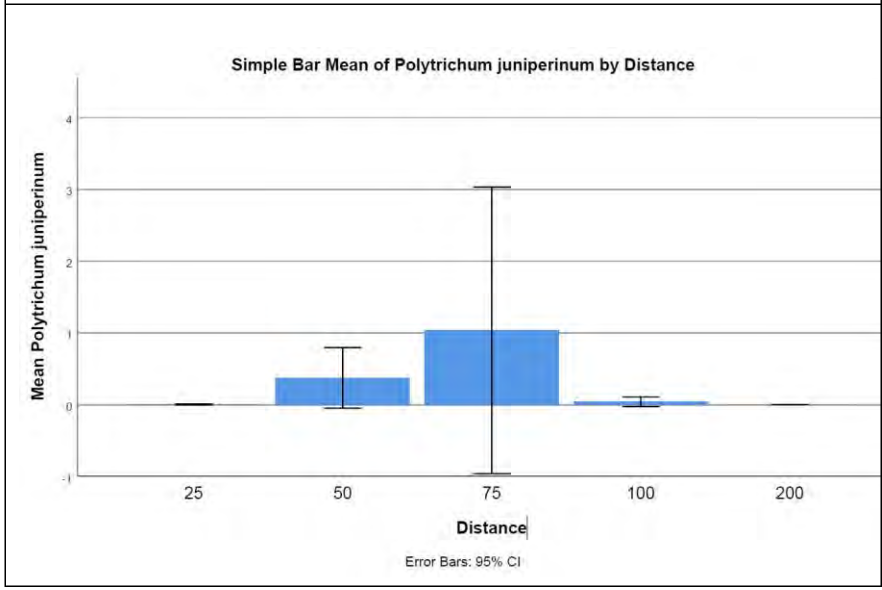

Simple Bar Mean of Luzula multiflora by Distance
Mean Luzula multiflora
0
0
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

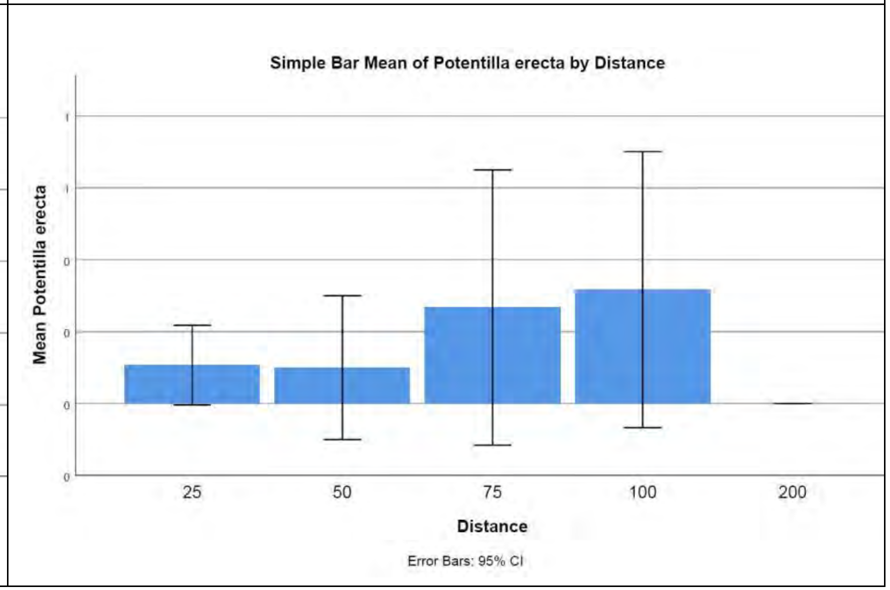


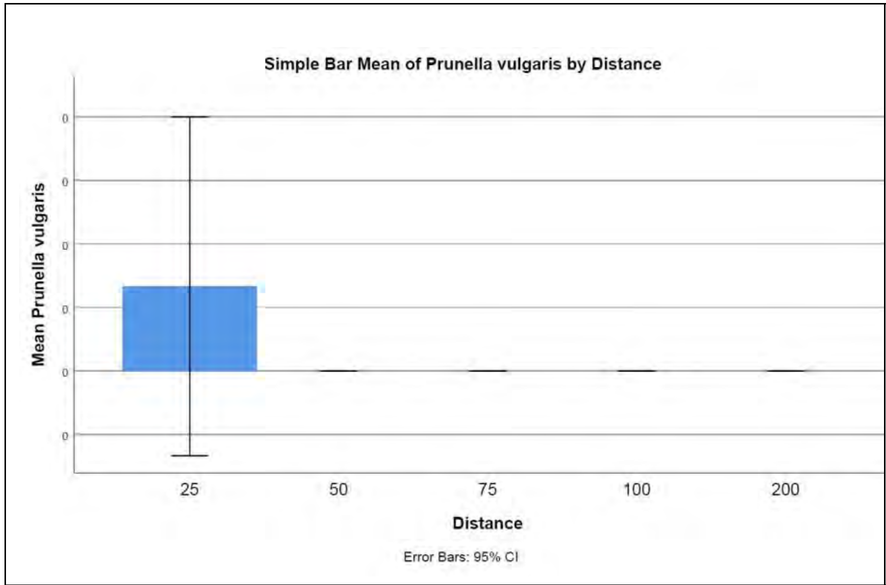
Simple Bar Mean of Molinia caerulea by Distance
Mean Molinia caerulea
0
20
40
60
25
50
75
100
200
Distance
Error Bars: 95% CI
Simple Bar Mean of Pedicularis sylvatica by Distance
Mean Pedicularis sylvatica
25
50
75
100
200
Distance
Error Bars: 95% CI
Simple Bar Mean of Pilosella officinalis by Distance
Mean Pilosella officinalis
25
50
75
100
200
Distance
Error Bars: 95% CI
Simple Bar Mean of Poa sp. by Distance
Mean Poa sp.
25
50
75
100
200
Distance
Error Bars: 95% CI

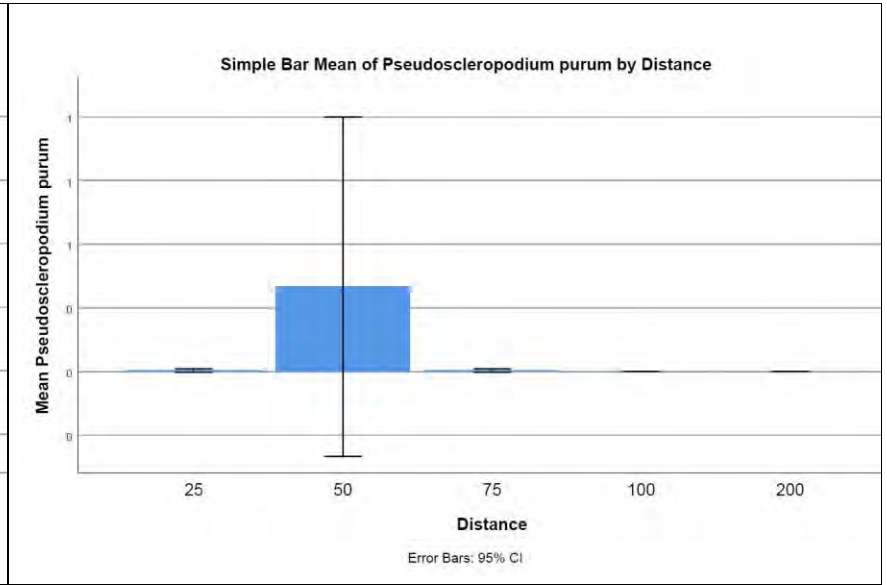

Simple Bar Mean of Polygala sepyllifolia by Distance
Mean Polygala sepyllifolia
25
50
75
100
200
Distance
Error Bars: 95% CI

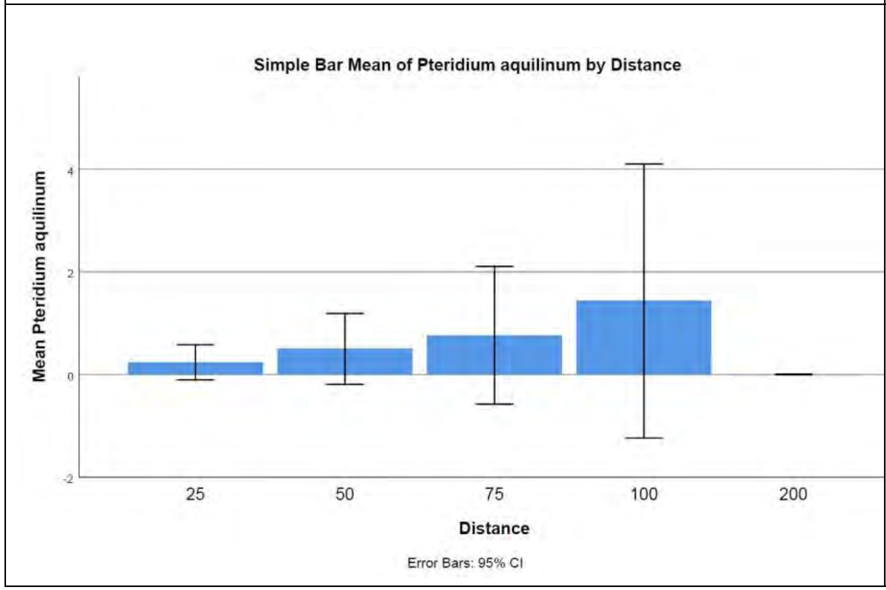

Simple Bar Mean of Polytrichum formosum by Distance
Mean Polytrichum formosum
25
50
75
100
200
Distance
Error Bars: 95% CI

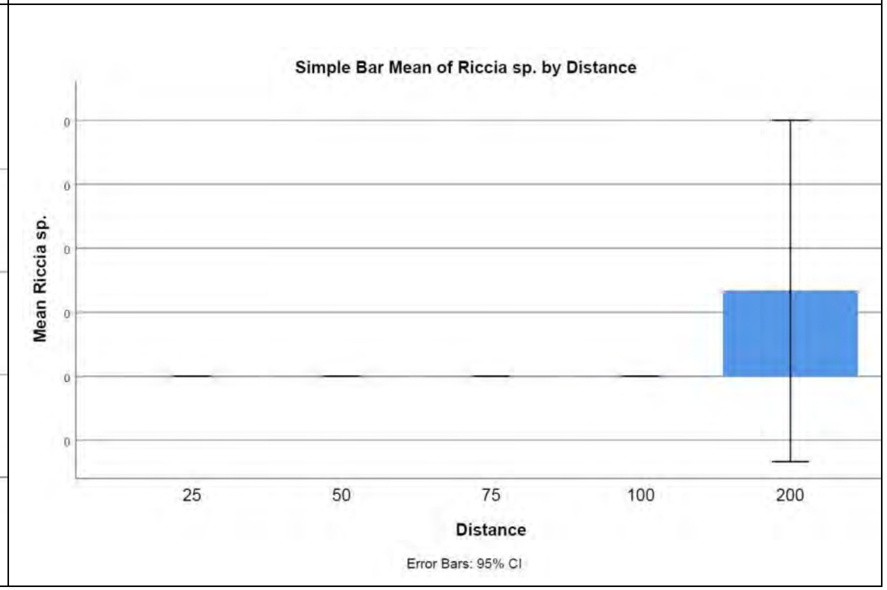

Simple Bar Mean of Polytrichum juniperinum by Distance
Mean Polytrichum juniperinum
4
3
2
1
0
-1
25
50
75
100
200
Distance
Error Bars: 95% CI

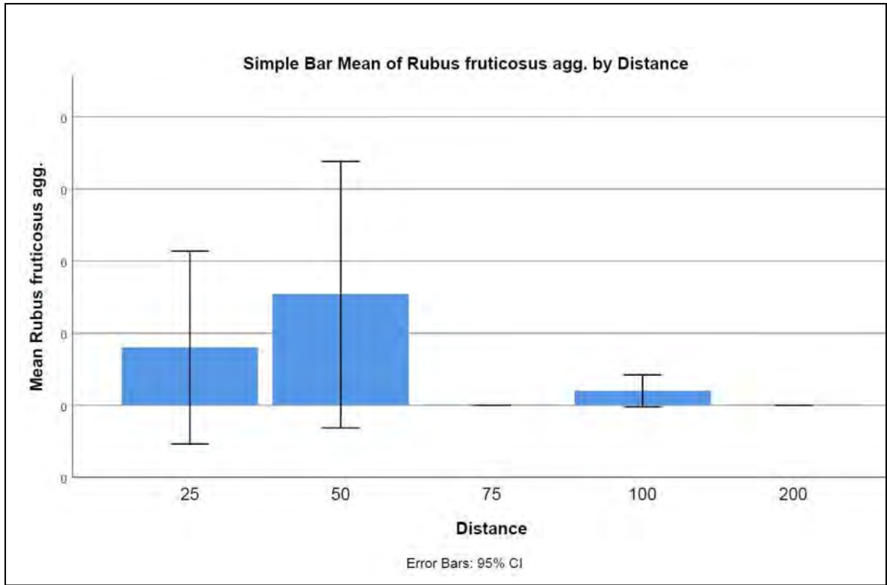

Simple Bar Mean of Potentilla erecta by Distance
Mean Potentilla erecta
25
50
75
100
200
Distance
Error Bars: 95% CI

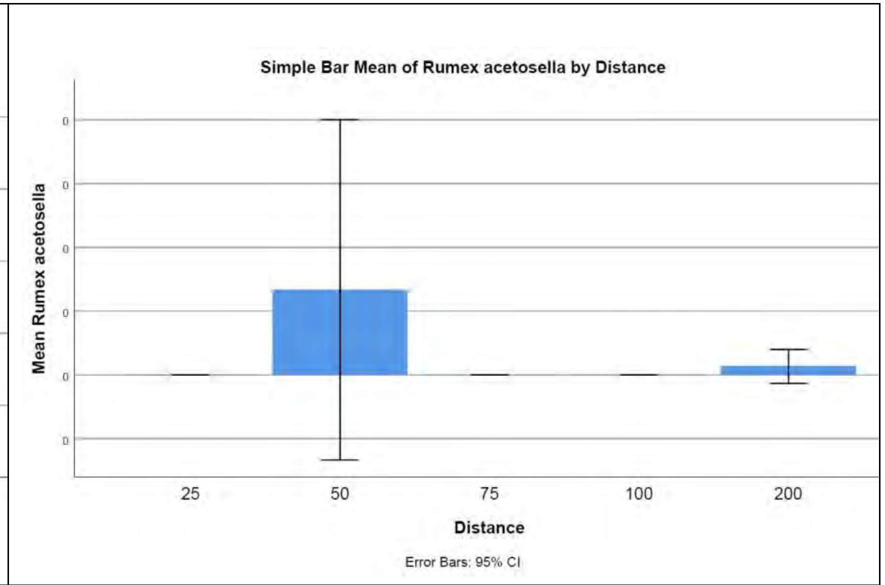

Simple Bar Mean of Prunella vulgaris by Distance
Mean Prunella vulgaris
0
0
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

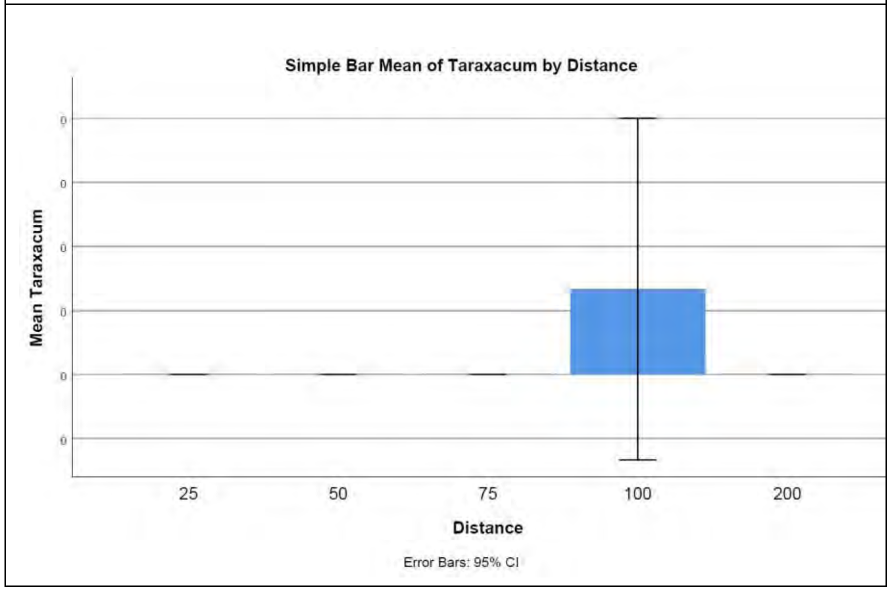

Simple Bar Mean of Pseudoscleropodium purum by Distance
Mean Pseudoscleropodium purum
1
1
1
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

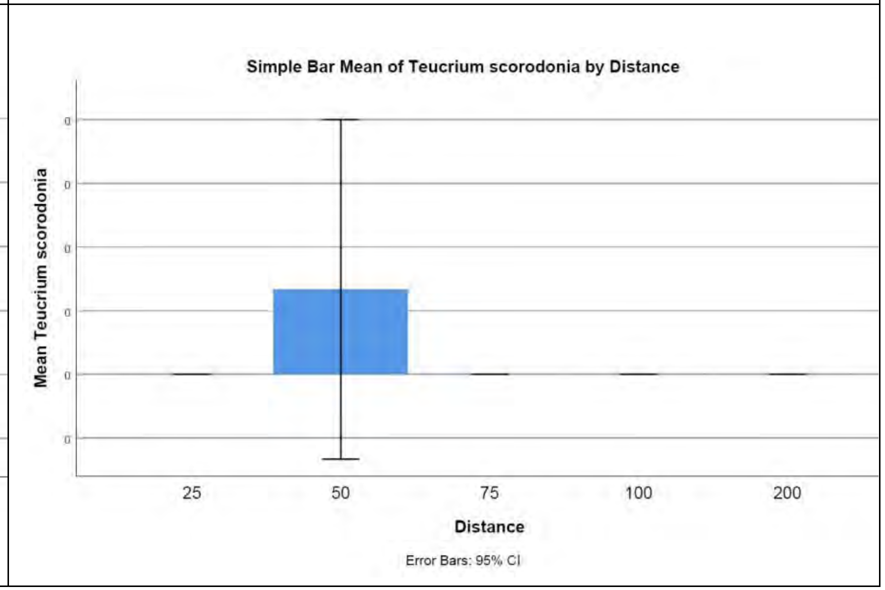

Simple Bar Mean of Pteridium aquilinum by Distance
Mean Pteridium aquilinum
4
2
0
-2
25
50
75
100
200
Distance
Error Bars: 95% CI

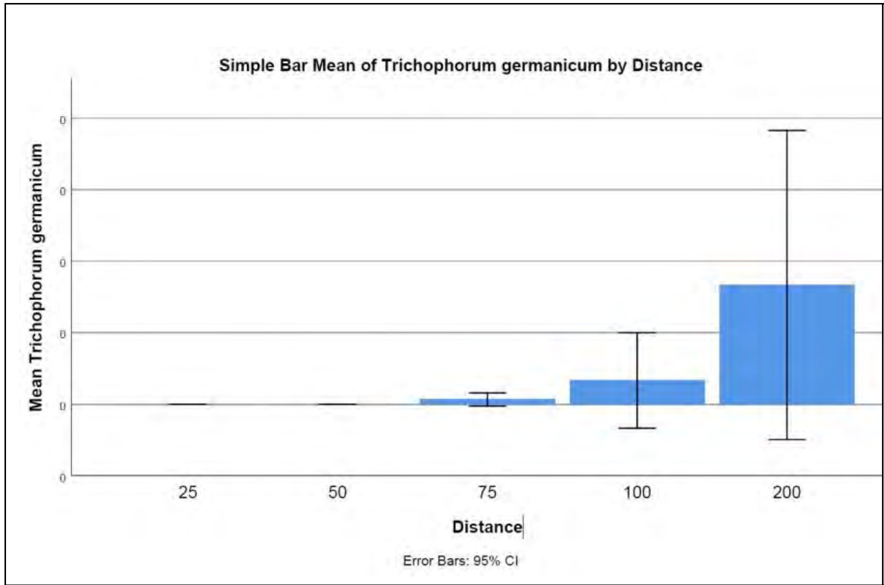

Simple Bar Mean of Riccia sp. by Distance
Mean Riccia sp.
0
0
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI

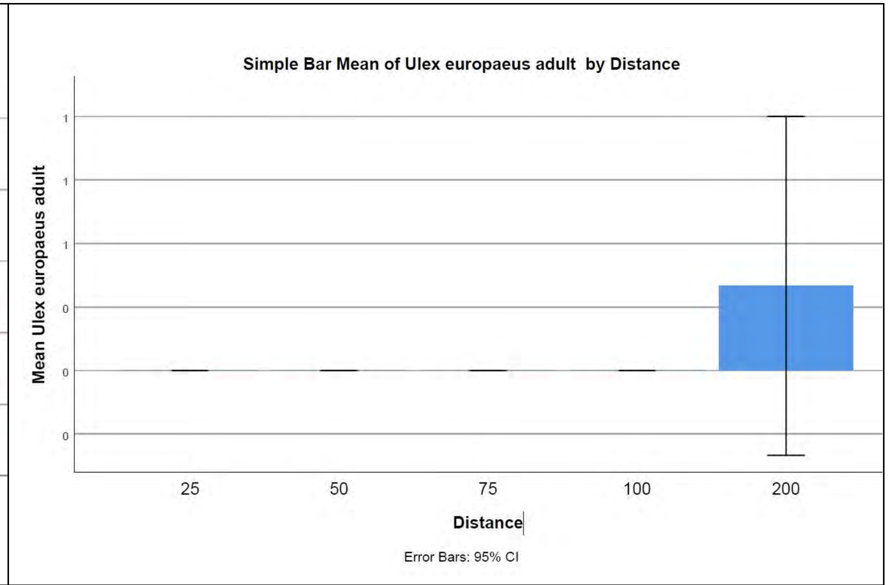

Simple Bar Mean of Rubus fruticosus agg. by Distance
Mean Rubus fruticosus agg.
25
50
75
100
200
Distance
Error Bars: 95% CI

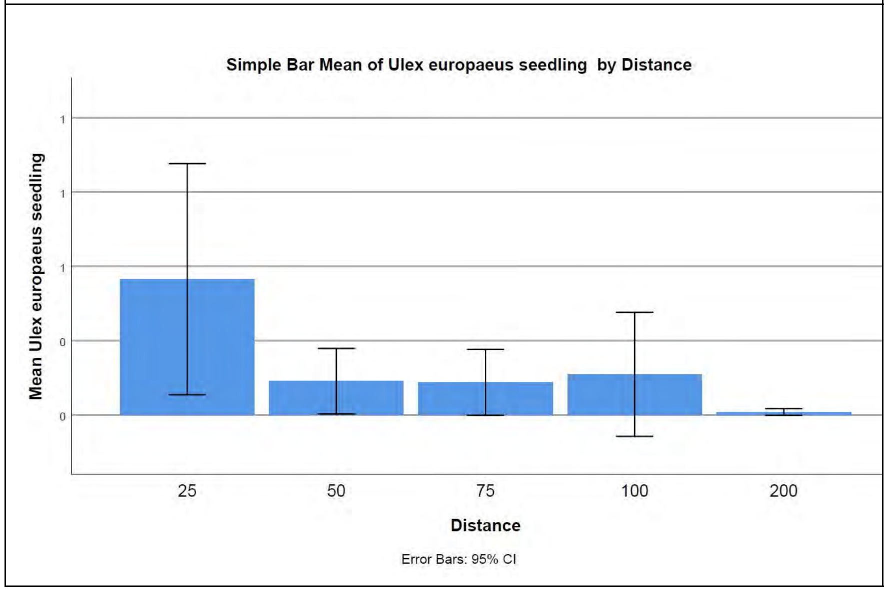

Simple Bar Mean of Rumex acetosella by Distance
Mean Rumex acetosella
25
50
75
100
200
Distance
Error Bars: 95% CI

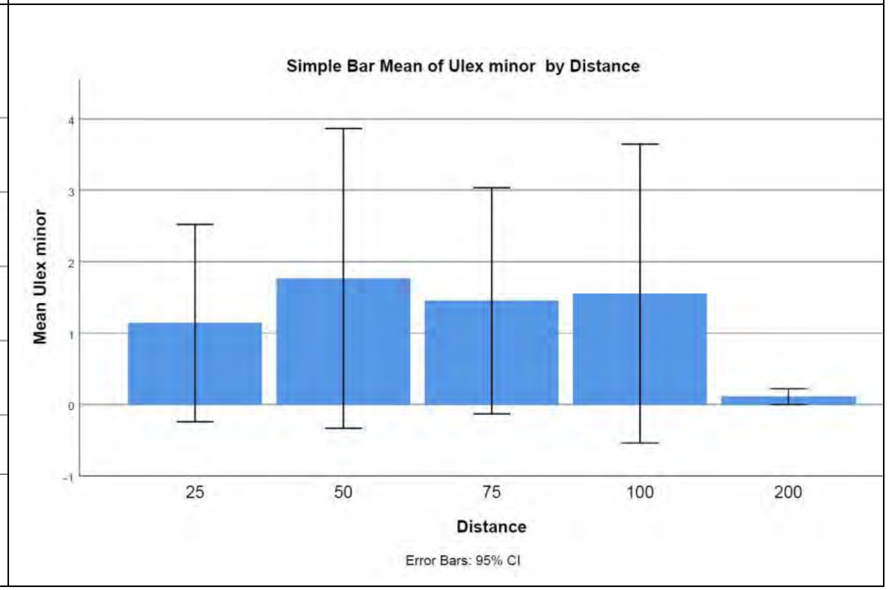

Simple Bar Mean of Taraxacum by Distance
Mean Taraxacum
25
50
75
100
200
Distance
Error Bars: 95% CI

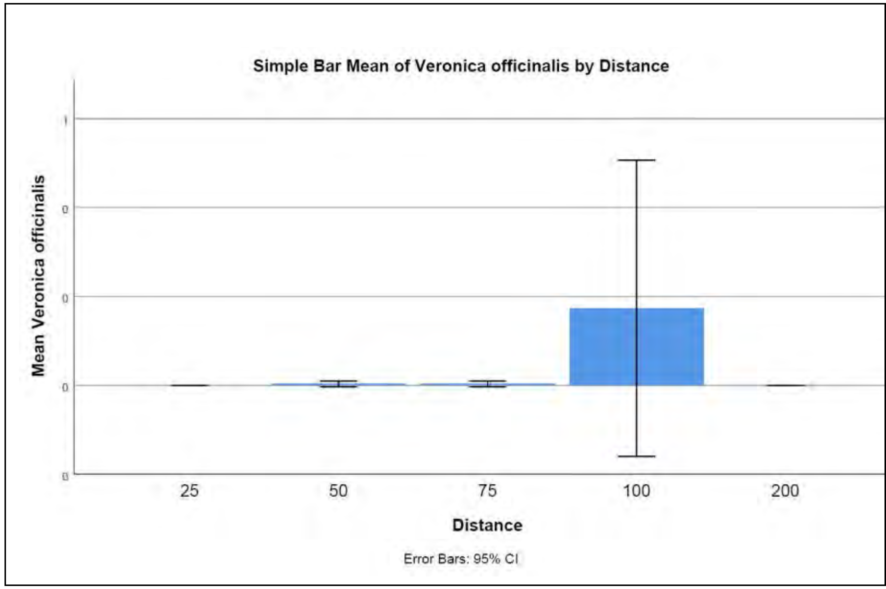

Simple Bar Mean of Teucrium scorodonia by Distance
Mean Teucrium scorodonia
25
50
75
100
200
Distance
Error Bars: 95% CI

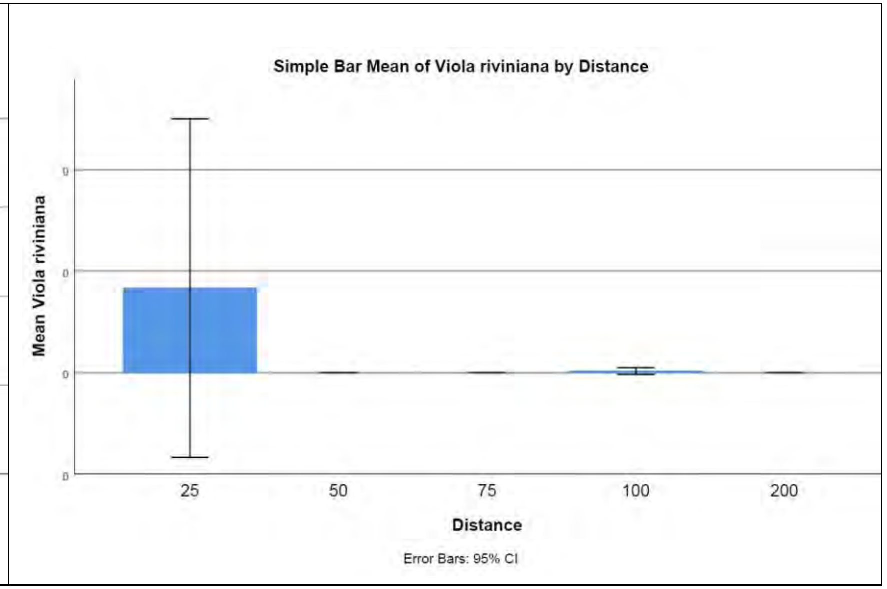

Simple Bar Mean of Trichophorum germanicum by Distance
Mean Trichophorum germanicum
0
0
0
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Ulex europaeus adult by Distance
Mean Ulex europaeus adult
1
1
1
0
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Ulex europaeus seedling by Distance
Mean Ulex europaeus seedling
1
1
1
0
0
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Ulex minor by Distance
Mean Ulex minor
4
3
2
1
0
-1
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Veronica officinalis by Distance
Mean Veronica officinalis
25
50
75
100
200
Distance
Error Bars: 95% CI


Simple Bar Mean of Viola riviniana by Distance
Mean Viola riviniana
25
50
75
100
200
Distance
Error Bars: 95% CI