Report on Critical Loads Assessment for Fleet Basin

Background

A request was received to undertake a critical loads assessment to assess the acid sensitivity of a number of watercourses affected by planned restocking within the Fleet Basin in Galloway. The adopted approach was as recommended by the Forestry Commission Practice Guide 'Managing forests in acid sensitive water catchments (Forestry Commission, 2014). This required the collection of a water sample from each stream under high flow conditions, preferably during the period January to March inclusive.

A total of nineteen streams were selected for sampling based on the extent of forest cover and catchment size (catchments <100 ha in area were excluded). Local staff identified precise sampling points and collected a water sample from each stream on 8 February 2022. All samples were taken during high flow conditions, as per the recommended methodology.

The water samples were sent by courier to Forest Research laboratories at Alice Holt Lodge in Surrey, where pH was determined on receipt and then samples filtered and stored in the fridge until analysed for the main cations and anions. The results were used to calculate the freshwater critical loads and exceedance values. It is important to note the following regarding the critical loads calculation:

1. Annual rainfall values were derived from the UKCIP09 5 km grid dataset for 1981-2010 and area weighed for each catchment. Run-off was calculated as rainfall/1.15 in view of annual rainfall being >1,000 mm.

2. Non-marine/pollutant sulphur deposition values were derived from the Centre for Ecology and Hydrology's UK 5 km grid dataset for 2016-18, for 100% forest cover. 5 km values were area weighted for each catchment but not adjusted/reduced for the actual level of forest cover present (assumed 100% cover). Adjusting for the <100% forest cover that is present in most catchments would make a small difference to the calculated values due to the low ambient level of sulphur deposition resulting from successful emission control and the relatively marginal nature of the forest scavenging effect.

3. Nitrogen deposition was calculated based on the observed nitrate concentration in the sampled water.

4. A threshold value of ANC 20 µeq/l was applied. This is considered to be very precautionary in view of its application to high flow samples.

Results & Discussion

The attached spreadsheet displays the chemical results and critical load calculations for the 19 sampled streams. Most of the sampled high flow waters were acidic or very acidic, with only two streams having a pH >7.0. Levels of non-marine base cations (which contribute buffering) were generally low to very low, with sodium values for all 19 streams calculated to be negative, as were eight of the streams for potassium and four for magnesium. This indicates that the sampled high flow event was a sea-salt event, which typically increases stream acidity due to cation exchange reactions in the soil (high sodium levels in rainwater forcing greater exchange with hydrogen and aluminium ions in acid soils). The sodium-chloride ratios in the stream samples reflected this temporary imbalance, with sodium levels only 0.7-0.8 of chloride. Consequently, critical load values were generally low to very low, with two streams, the Cardoon Burn Tributary and Pulwhanne Burn, exhibiting negative critical loads (reflecting the extremely low level of non-marine base cations present).

The sea-salt nature of the sampled event increases the likelihood of critical load exceedance, although this also depends on levels of acid deposition, which are low due to ongoing emission control. Sulphur deposition was part measured and part modelled based on the three-year period of 2016-18, which represents the latest available data. In line with expectations, levels of pollutant sulphate (estimated from measured concentrations) were very low in the high flow samples, with twelve of the 19 streams having non-marine sulphate concentrations <10 µeq/l, including two displaying negative values. Nitrate concentrations were also generally very low, with 11 of the 19 streams having values <10 µeq/l nitrate-N. Consequently, calculated values of net nitrogen deposition, the other component of acid deposition, were very low, and when combined with sulphur, gave low values for total acid deposition.

Notwithstanding the sea-salt driven nature of the sampled high flow event, only four sites (Cardoon Burn tributary, Pulwhanne Burn, Little Water of Fleet 2 and Fell of Fleet) showed critical load exceedance, although a fifth stream (Cleugh of Eglon Burn) had a zero value. A further three streams (Lane of the Loop, Nick of the Dead Man's Banes and Penwhaile Burn) had very low levels of critical load protection (0.02-0.04 keq/ha/y), with total net acid deposition within 88-97% of the critical load. Consequently, according to the guidance, these three streams should be re-sampled on another two occasions to check the result; it would also make sense to resample the Cleugh of Eglon Burn site. The other eleven streams (Craiglowrie Burn, Benmeal Burn, North of Darncree, Corse Burn, Burnfoot Burn, Little Water of Fleet Upper, Upper Barlay Burn, Barlay Burn, Little Water of Fleet, Cleugh Burn and Big Water of Fleet) had a sufficient margin of critical load protection (total acid deposition ranging between 7-71% of the critical load) to allow normal restocking to proceed without checking or mitigation.

A summary of the calculated critical loads (CL), total acid deposition (Total Dep) and exceedance (CLEX) values for the nineteen sampled streams is provided below, with red used to display critical load exceedance, yellow marginal protection and green non-exceedance, with an acceptable safety margin. The location of these catchments and their critical load status is displayed in the accompanying map at the end of the report.

1. Cardoon Burn tributary at NX 54629 65735: CL = -0.33 keq/ha/y; Total Dep = 0.23 keq/ha/y; CLEX = 0.56 keq/ha/y

2. Cleugh of Eglon Burn at NX 54563 66735: CL = 0.52 keq/ha/y; Total Dep = 0.52 keq/ha/y; CLEX = 0.00 keq/ha/y

3. Craiglowrie Burn at NX 55105 66718; CL = 0.68 keq/ha/y; Total Dep = 0.42 keq/ha/y; CLEX = -0.26 keq/ha/y

4. Benmeal Burn at NX 55867 65796; CL = 0.69 keq/ha/y; Total Dep = 0.35 keq/ha/y; CLEX = -0.34 keq/ha/y

5. Lane of the Loop at NX 56284 66168: CL = 0.32 keq/ha/y; Total Dep = 0.28 keq/ha/y; CLEX = -0.04 keq/ha/y

6. Nick of the Dead Man's Banes at NX 56482 67174: CL = 0.46 keq/ha/y; Total Dep = 0.43 keq/ha/y; CLEX = -0.03 keq/ha/y

7. Little Water of Fleet 2 at NX 57855 69165: CL = 0.34 keq/ha/y; Total Dep = 0.49 keq/ha/y; CLEX = 0.15 keq/ha/y

8. Fell of Fleet at NX 58035 69242: CL = 0.30 keq/ha/y; Total Dep = 0.39 keq/ha/y; CLEX = 0.10 keq/ha/y

9. North of Darncree at NX 58857 67267: CL = 0.71 keq/ha/y; Total Dep = 0.43 keq/ha/y; CLEX = -0.28 keq/ha/y

10. Corse Burn at NX 57775 66409: CL = 0.64 keq/ha/y; Total Dep = 0.29 keq/ha/y; CLEX = -0.35 keq/ha/y

11. Burnfoot Burn at NX 59517 65096: CL = 1.06 keq/ha/y; Total Dep = 0.50 keq/ha/y; CLEX = -0.56 keq/ha/y

12. Little Water of Fleet Upper at NX 58465 64748: CL = 1.33 keq/ha/y; Total Dep = 0.59 keq/ha/y; CLEX = -0.74 keq/ha/y

13. Upper Barlay Burn at NX 62122 58413: CL = 4.48 keq/ha/y; Total Dep = 0.49 keq/ha/y; CLEX = -4.00 keq/ha/y

14. Barlay Burn at NX 59916 57874: CL = 10.06 keq/ha/y; Total Dep = 0.70 keq/ha/y; CLEX = -9.36 keq/ha/y

15. Little Water of Fleet at NX 58533 60950: CL = 1.42 keq/ha/y; Total Dep = 0.59 keq/ha/y; CLEX = -0.83 keq/ha/y

16. Cleugh Burn at NX 58555 61964: CL = 2.08 keq/ha/y; Total Dep = 0.31 keq/ha/y; CLEX = -1.77 keq/ha/y

17. Big Water of Fleet at NX 57679 61143: CL = 0.63 keq/ha/y; Total Dep = 0.45 keq/ha/y; CLEX = -0.18 keq/ha/y

18. Pulwhanne Burn at NX 55700 62818: CL = -0.11 keq/ha/y; Total Dep = 0.23 keq/ha/y; CLEX = 0.34 keq/ha/y

19. Penwhaile Burn at NX 56197 62653: CL = 0.31 keq/ha/y; Total Dep = 0.30 keq/ha/y; CLEX = -0.02 keq/ha/y

Conclusions

The results of the critical loads assessment indicates that four of the sampled stream catchments are at risk of further acidification if restocking were to exceed 30% catchment cover of closed canopy forest (>15 years age). Consideration should therefore be given to reducing the extent of forest cover and/or amending the nature of the restocked forest in these catchments to reduce the potential impact (as per guidance). Another four stream catchments have a very low level of critical load protection and should be resampled (on two occasions) to check the result. In view of the sea-salt nature of the sampled event, it is likely that resampling would confirm catchment protection, allowing forest restocking to proceed without the need for mitigation measures. The results for the other eleven stream catchments show waters to be sufficiently protected from acidification to allow normal restocking practice without the need for checking or mitigation.

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15 August 2022

Reference

Forestry Commission (2014). *Managing forests in acid sensitive water catchments.* Forestry Commission Practice Guide. Forestry Commission, Edinburgh (24pp).

Map displaying the calculated critical load status of sampled stream catchments in the Fleet Basin (Red catchments exhibit critical load exceedance and therefore require mitigation to reduce the risk of restocking increasing surface water acidification (e.g. by reducing the extent of forest cover and/or amending the nature of the restocked forest); yellow catchments show a marginal level of critical load protection and require resampling on two further occasions to check the result and confirm that no mitigation measures are needed to prevent acidification; and green catchments display stream waters that are sufficiently protected from further acidification to allow normal forest restocking.