Ministry for the Environment
Manatū Mō Te Taiao

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19-D-01899, 19-D-02250

s 9(2)(a)
[redacted]
DairyNZ
s 9(2)(a) @dairynz.co.nz

Dear s 9(2)(a)

Thank you for your emails of 6 September and 1 October requesting the following under the Official Information Act 1982 (the Act):

6 September – 19-D-01899

> *I was just looking at pg 54 (appendix 4) of STAG technical document - is there a technical document / memorandum providing more information on derivation of values shown in Table A4-3 ? Given their potential importance, it would be good to see a detailed 'audit trail' for the numbers (Im assuming that the numbers in A4-3 for each trophic group are averages – ie macroinvertebrates – thresholds are average of the 3 metrics)*

1 October – 19-D-02250

> *Im not sure if you have an information request email (apologies if im not directing these to the right address) ; but for the purposes of trying to understand the technical merits of what has been recommended by the STAG - I wanted to read over all the minutes, but noticed there are only minutes from two meetings (oct and Nov 2018)*
>
> *By contrast, I see the FLG has minutes from 11 meetings – and within these minutes, a large number of presentations /briefing papers were provide/given to the FLG by members of the STAG and Water Taskforce.*
>
> *So two questions / requests are:*
>
> *1) Now that the advisory process has concluded - are all the documents / presentations referred to in the FLG meeting minutes available to 'the public' ? and if not could these be made available ?*
>
> *a. Of particular interest are the STAG presentations - as currently we have very little information to assess the robustness of the ecosystem health nutrient DIN and DRP*
>
> *2) Would it be possible to get copies of the STAG meeting minutes (assuming there were any) - again, this would help with the whole issue of 'transparency'*

The Ministry for the Environment has interpreted your requests as including the Science and Technical Advisory Group's (STAG):

- meeting minutes and documents
- documents provided to David Hamilton to peer review the development of nutrient attributes
- Powerpoint presentations to STAG relating to the nutrient attributes.

We have identified 37 documents in scope of your request, as listed in the attached table.

The STAG meeting minutes and documents are publicly available on the Ministry's website (https://www.mfe.govt.nz/fresh-water/science-and-technical-advisory-group). Because they are publicly available, they are being refused for release under section 18(d) of the Act.

For the documents that are not already publicly available, some information identifying individual STAG members and their personal contact details has been withheld under the following sections of the Act:

9(2)(a)	*it is necessary to withhold the information to protect the privacy of natural persons*
9(2)(g)(i)	*release of the information at issue would inhibit the future exchange of free and frank opinions*

In terms of section 9(2) of the Act, I am satisfied that, in the circumstances, the withholding of this information is not outweighed by other considerations that render it desirable to make the information available in the public interest.

The STAG provided their final advice to the Minister for the Environment in their report, which is available on the Ministry's website (https://www.mfe.govt.nz/publications/fresh-water/freshwater-science-and-technical-advisory-group-report-minister-environment). The documents listed in the table below are draft documents and show the iterative nature of the process to develop the final report. They should be considered together with the final STAG report as a record of the development of the proposals. In particular, Document 25 in the list below shows an important step in the analysis which followed the analyses in documents 27 and 28.

STAG members are preparing a summary of the attribute development process and this will be made available as soon as possible. We would appreciate your submission on the current consultation to help us inform policy development on these proposals.

You have the right to seek an investigation and review by the Office of the Ombudsman of my decision to withhold information relating to this request, in accordance with section 28(3) of the Act. The relevant details can be found on their website at: www.ombudsman.parliament.nz.

Please note that due to the public interest in our work the Ministry for the Environment publishes responses to requests for official information on our website on our OIA responses page shortly after the response has been sent.

If you have any queries about this, please feel free to contact our Executive Relations team.

Yours sincerely

Martin Workman
Director, Water

List of documents

Document no.	Document date	Content	Decisions	OIA sections applied	Page
Meeting minutes					
1	October 2018	Document: STAG Meeting minutes - 18 & 19 October 2018	Refused for release	s(18)d	
2	November 2018	Document: STAG Meeting minutes - 29 November 2018	Refused for release	s(18)d	
3	January 2019	Document: STAG Meeting minutes - 24 January 2019	Refused for release	s(18)d	
4	February 2019	Document: STAG Meeting minutes - 26 February 2019	Refused for release	s(18)d	
5	March 2019	Document: STAG Meeting minutes - 26 March 2019	Refused for release	s(18)d	
6	April 2019	Document: STAG Meeting minutes - 16 April 2019	Refused for release	s(18)d	
7	May 2019	Document: STAG Meeting minutes - 1 May 2019	Refused for release	s(18)d	
8	June 2019	Document: STAG Meeting minutes - 13 June 2019	Refused for release	s(18)d	
9	June 2019	Document: STAG Meeting minutes - 24 June 2019	Refused for release	s(18)d	
Meeting documents					
10	October 2018	Document: STAG meeting docs 18 19 October	Refused for release	s(18)d	

Document no.	Document date	Content	Decisions	OIA sections applied	Page
11	November 2018	Document: STAG meeting docs 29 November	Refused for release	s(18)d	
12	January 2019	Document: STAG meeting docs 24 January	Refused for release	s(18)d	
13	January 2019	Document: STAG meeting docs 24 January sediment technical appendix Paper to inform STAG discussion on sediment at January 2019 meeting	Refused for release	s(18)d	
14	February 2019	Document: STAG additional meeting docs Nutrient attribute explanation 25 Feb Paper detailing proposed nutrient tables to inform STAG discussion at February meeting	Refused for release	s(18)d	
15	February 2019	Document: STAG meeting docs 26 February	Refused for release	s(18)d	
16	March 2019	Document: STAG meeting docs 26 March	Refused for release	s(18)d	
17	March 2019	Document: STAG meeting docs 26 March Maintain or Improve Paper to inform STAG discussion on the requirement to 'maintain or improve' water quality at March meeting	Refused for release	s(18)d	
18	April 2019	Document: STAG additional meeting docs Nutrient sub-group summary 12 April Proceedings of sub-group formed by STAG members to discuss nutrients in more detail	Refused for release	s(18)d	

Document no.	Document date	Content	Decisions	OIA sections applied	Page
19	April 2019	Document: STAG meeting docs 16 April	Refused for release	s(18)d	
20	May 2019	Document: STAG meeting docs 1 May	Refused for release	s(18)d	
21	May 2019	Document: STAG additional meeting docs Proposed nutrient attributes 2 May Following the 1 May meeting, STAG members requested summary tables of nutrient attributes. This document contains the proposed nutrient tables as of 2 May.	Refused for release	s(18)d	
22	May 2019	Document: STAG additional meeting docs Proposed Nutrient Attribute tables for the NPS 22 May An expanded explanation of the derivation of the nutrient attributes as of 22 May	Refused for release	s(18)d	
23	May 2019	Document: STAG additional meeting docs David Hamilton review STAG nutrient attributes 31 May Review of STAG's development of the nutrient attributes	Refused for release	s(18)d	
24	June 2019	Document: STAG meeting docs 13 June	Refused for release	s(18)d	
25	June 2019	Document: STAG additional meeting docs Comparison of MCI vs nutrient relationship This paper examined the effect of using different datasets on the relationship between Macroinvertebrate Community Index	Refused for release	s(18)d	

Document no.	Document date	Content	Decisions	OIA sections applied	Page
		and nutrient, and informed STAG's report recommendations			
Additional documents provided to David Hamilton for peer review					
26	2018	STAG 26 Feb Death et al 2018 Nutrient criteria for NZ rivers Paper detailing proposed nutrient criteria – forms basis for further STAG discussions http://pnrp.gw.govt.nz/assets/Uploads/HS4-S308-Fish-and-Game-Russell-Death-Expert-evidence-26-January-2018-Attachment2.pdf	Refused for release	s(18)d	
27	11 April 2019	Email: RE: Nutrient sub-group – decision needed about sub-group summary Email plus attachment containing the results of modelling analyses – showing N is a key predictor of MCI	Released with minor redactions	9(2)(g)(i)	1
28	12 April 2019	Email: [REDACTED] new analysis Email plus attachment containing the results of modelling analyses – showing little relationship between N and MCI	Released with minor redactions	9(2)(a) 9(2)(g)(i)	8
29	April 2019	STAG 16 April agenda and priority papers (note: same as document 19)	Refused for release	s(18)d	
30	8 May 2019	Email: Your query about nutrient narrative sub-group correspondence STAG discussions about attributes	Released with minor redactions	9(2)(g)(i)	11
31	6 May 2019	Proposed nutrient attributes 6 May STAG's proposed nutrient attribute tables (note: same as document 21)	Refused for release	s(18)d	
32	22 May 2019	Methods and results of analysis to produce nutrient attribute tables for ecosystem health	Refused for release	s(18)d	

Document no.	Document date	Content	Decisions	OIA sections applied	Page
		Expanded explanation of the derivation of the nutrient attributes as of 22 May (note: same as document 22)			
33	22 May 2019	Email: FW: STAG nutrients and ecosystem health discussion Summary of STAG recommendations	Released with minor redactions	9(2)(a) 9(2)(g)(i)	16
STAG Powerpoint presentations					
34	26 February 2019	Powerpoint presentation by Cathy Kilroy to STAG Title: Developing relationships between periphyton and environmental variables	Released in full		23
35	26 February 2019	Powerpoint presentation by Chris Nokes to STAG Title: Nitrate in drinking water	Released in full		58
36	26 February 2019	Powerpoint presentation by Russell Death to STAG Subject: derivation of nitrogen and phosphorus guidelines using multiple lines of evidence First slide is entitled: "Compiled lots of readily available data"	Released in full		72
37	26 February 2019	Powerpoint presentation by Ton Snelder to STAG Title: Nutrient concentration targets to achieve periphyton biomass objectives	Released in full		82

Jennifer Price

From:	[redacted]
Sent:	Thursday, 11 April 2019 6:49 PM
To:	Jennifer Price; [redacted]
Cc:	Ton Snelder (landwaterpeople.co.nz); Isaac Bain
Subject:	RE: Nutrient sub-group - decision needed about sub-group summary
Attachments:	BRT exploration of invertebrate metrics.docx
Follow Up Flag:	Follow up
Flag Status:	Flagged

Hi all

I'm happy with these. Given the limitations of linear regression, as a complementary analysis, I've used boosted regressions trees to explore the relative influence of nutrients and natural factors in predicting macroinvertebrate indicators. In all cases, nitrate-nitrogen was the most influential predictor (see attached)

Cheers
[redacted]

-----Original Message-----
From: Jennifer Price <Jennifer.Price@mfe.govt.nz>
Sent: Thursday, 11 April 2019 12:08 PM
To: [redacted]
Cc: Ton Snelder (landwaterpeople.co.nz) <ton@landwaterpeople.co.nz>; Isaac Bain <Isaac.Bain@mfe.govt.nz>
Subject: Nutrient sub-group - decision needed about sub-group summary

Hi all,
Attached are two documents:
1. Nutrient sub-group summary: This contains the attribute tables and meeting notes. If everybody is happy with this I can send it to STAG - please let me know whether that is OK or not.
2. The tracked changes version of the meeting notes from 5 April, showing updates based on your emails.
Cheers
Jen

-----Original Message-----
From: Jennifer Price
Sent: Thursday, 11 April 2019 9:13 AM
To: [redacted]
Cc: [redacted] Ton Snelder (landwaterpeople.co.nz) <ton@landwaterpeople.co.nz>; Isaac Bain <Isaac.Bain@mfe.govt.nz>; [redacted]
Subject: RE: Phone conference - nutrient sub-group

Hi all,
Thanks for all your work on this. I am conscious of next week's meeting coming up soon so would like to make a plan for getting the sub-group recommendations to the STAG.
One option would be:
1. I will collate the info from [redacted] below, with the meeting notes as amended by the sub-group members, 2. Sub-group members approve, 3. I will send to STAG.

Is everyone happy with this approach?
Cheers
Jen

-----Original Message-----
From: 9(2)(g)(i) [redacted]
Sent: Tuesday, 9 April 2019 6:44 PM
To: Jennifer Price <Jennifer.Price@mfe.govt.nz>
Cc: 9(2)(g)(i) [redacted] Ton Snelder (landwaterpeople.co.nz) <ton@landwaterpeople.co.nz>; 9(2)(g)(i) [redacted]
Subject: RE: Phone conference - nutrient sub-group

Hi all

I have some mock-up tables attached for feedback. I have created them so:
- Total nutrients are used, not dissolved;
- Ecosystem processes are included;
- Groups are weighted equally (or minimum for option 3).
- Option 3 is an option that protects for the most stringent group in each band. This is provided given as this theme has arisen a few times in STAG and we were asked how we could build in precaution.
- Bands have been harmonised with the attribute tables proposed for ASPM and IBI and existing chlorophyll a attribute (Jen has these). We can re-calibrate the numbers if STAG changes the tables.

In each table there are three columns, each presenting a different option.

Options:
1. Average all groups equally, including percentile analysis.
2. Average all groups equally, excluding percentile analysis (as not correlated with ecosystem health metrics).
3. Protect for the most stringent group, excluding percentile analysis (as not correlated with ecosystem health metrics).

What option should we go for?

Cheers
9(2) [redacted]

-----Original Message-----
From: 9(2)(g)(i) [redacted]
Sent: Tuesday, 9 April 2019 11:05 AM
To: 9(2)(g)(i) [redacted] Jennifer Price <Jennifer.Price@mfe.govt.nz>
Cc: 9(2)(g)(i) [redacted] Ton Snelder (landwaterpeople.co.nz) <ton@landwaterpeople.co.nz>; 9(2)(g)(i) [redacted]
Subject: RE: Phone conference - nutrient sub-group

Hi All,

Good job, Jen. I've made a few suggestions on your notes as well.

I generally agree with 9(2)(g)(i) [redacted] emailed comments too.

Cheers!
9 [redacted]

-----Original Message-----
From: [redacted]
Sent: Tuesday, 9 April 2019 8:44 AM
To: Jennifer Price <Jennifer.Price@mfe.govt.nz>
Cc: [redacted] Ton Snelder (landwaterpeople.co.nz) <ton@landwaterpeople.co.nz>; Isaac Bain <Isaac.Bain@mfe.govt.nz>
Subject: Re: Phone conference - nutrient sub-group

Hi Jen

Thanks Jen, looking good.

The only part I'm still a bit uncertain about is "Managing N on its own will not deliver the co-benefits". Not sure what's meant by "co-benefits" - do you mean be a silver bullet? I agree that it won't be a silver bullet.

Though I do think it's essential because nutrients are so fundamental to the way ecosystems work. There will always be environmental uptake of nutrients by the food web, and in turn affecting cycling and throughflow. Unfortunately the responses are often emergent properties that can be difficult to measure. So i support the part where you say "but collectively, attributes can go a long way towards providing for ecosystem health."

Thanks
[redacted]

> On 9/04/2019, at 8:26 AM, Jennifer Price <Jennifer.Price@mfe.govt.nz> wrote:
>
> Managing N on its own will not deliver the co-benefits

An exploration of factors predicting macroinvertebrate indices

Objective: To explore the extent to which nutrients and natural environmental factors can predict macroinvertebrate indices, specifically the MCI, %EPT-abundance and ASPM.

Linear regression has been used to explore relationships between MCI and nutrients for different REC and FENZ river classes. Some classes yield significant relationships, others did not. Linear regression has five key assumptions which should be met prior to analysis. If they are not met, then careful interpretation of findings is needed, with the assumptions made clear otherwise hypothesis. These assumptions are (1) the relationship is indeed linear, (2) residuals are normally distributed, (3) No or little multicollinearity, (4) no auto-correlation, (5) there is homogeneity of variance across the gradient (homoscedasticity), (6) the sample size is sufficiently large (ie 20+). Whilst pre-processing, such as transformations and initial design, can allow for some assumptions to be met, data limitations can constrain the usefulness of linear regression. The explorations using linear regressions (MCI vs nutrients) by REC and FENZ classes showed substantial heteroscedasticity, non-normal distribution of residuals, and data scarcity or inconsistent data extent.

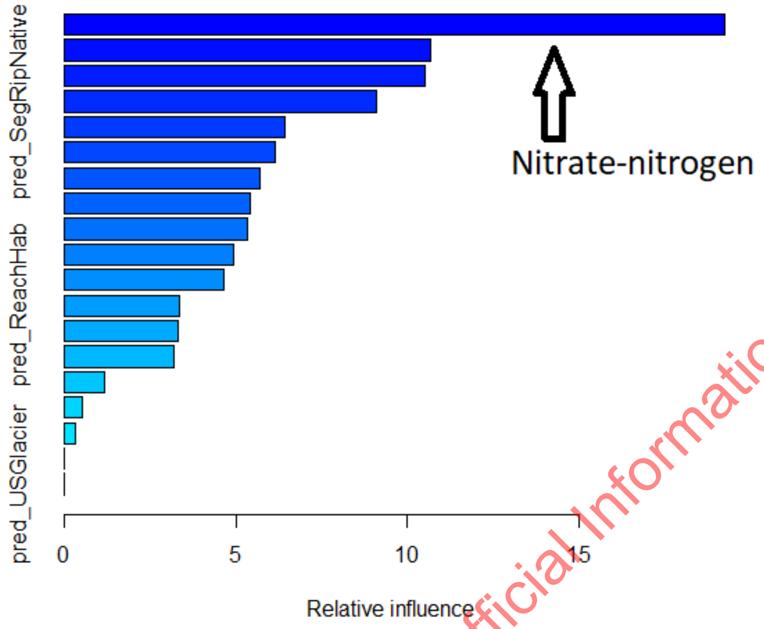
As an alternative exploration, Boosted Regression Trees (BRT) may provide more informative insight into the extent to which macroinvertebrate indices can be predicted by nutrients alongside other natural factors. Boosted Regressions Tree (BRT) models are capable of fitting interactions and non-linear predictors, can handle non-normal error terms and missing values, and can identify the most informative predictors whilst ignoring irrelevant ones.

Here BRTs are used to model MCI, %EPT-abundance and the ASPM from the factors in Table 1 (sourced from the FENZ geodatabase and Larned (2016). For MCI, three explorations were undertaken: (1) using national SOE dataset (2012-2016), (2) Prof Death's dataset, and (3) the national SOE dataset and Prof Death's combined. BRTs were ran with a tree complexity of 10, learning rate of 0.001, and cross-validated using a bag fraction of 0.2.

Table 1. Predictors used in BRT explorations.	
DRP_State	USAvgSlope
NO3N_State	USCalcium
SegJanAirT	USHardness
SegLowFlow	USPhosporus
SegFlow4th	USPeat
SegFlowVariability	USLake
SegSlopeSqrt	USWetland
SegRipShade	USNative
SegRipNative	USGlacier
DSDist2Coast	ReachSed
USAvgTNorm	ReachHab

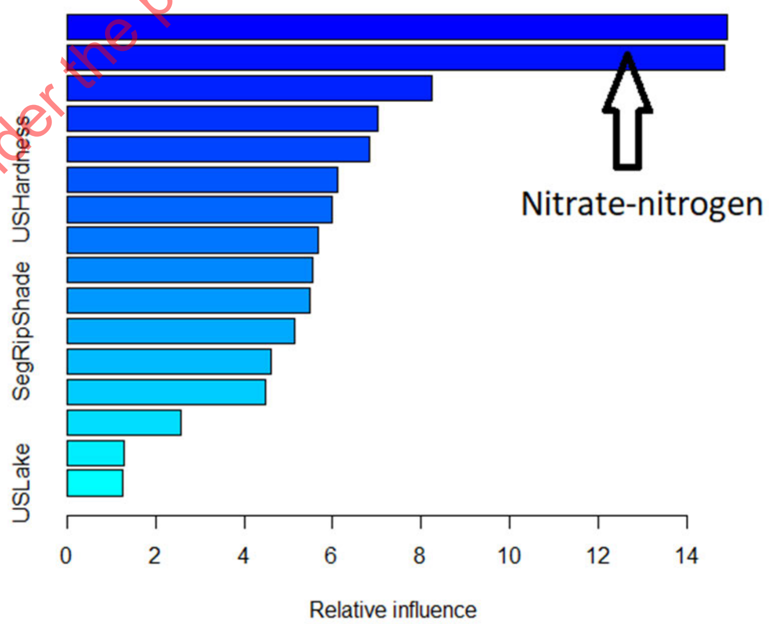
Predicting MCI from Prof Death's dataset

This exploration had a cross-validated correlation of 0.799 (se=0.013). Nitrate-nitrogen was the best predictor, followed by flow variability and native riparian cover.



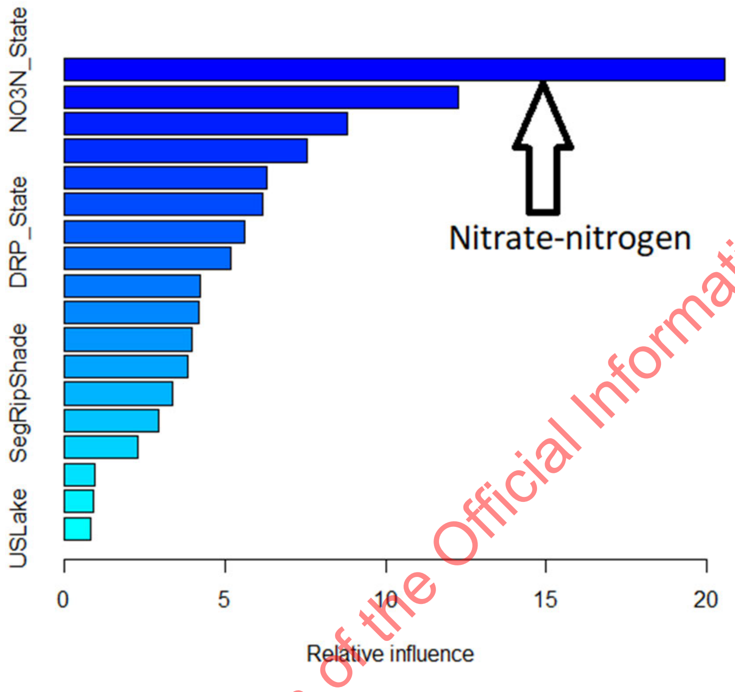
Predicting MCI from the national SOE dataset

This exploration had a cross-validated correlation of 0.742 (se=0.011). Nitrate-nitrogen was the best predictor, followed by flow variability, slope, January air temperature and native riparian cover.



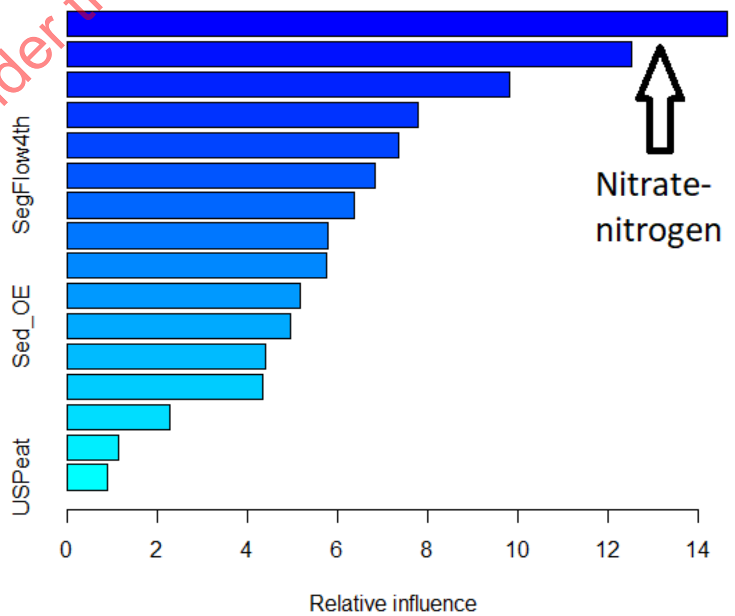
Predicting MCI from the national SOE dataset and Prof Death's dataset

This exploration had a cross-validated correlation of 0.797 (se=0.007). Nitrate-nitrogen was the best predictor, followed by flow variability, air temperature, slope and native riparian cover.



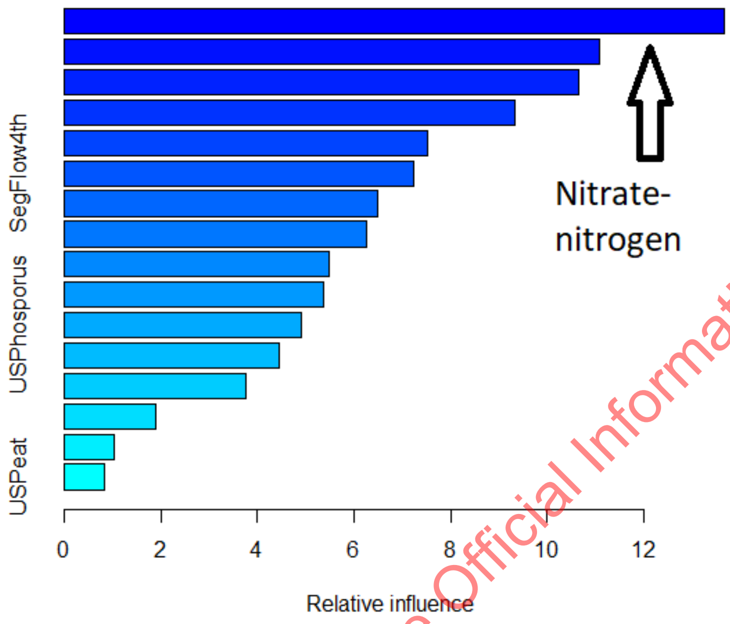
Predicting ASPM from the national SOE dataset

This exploration had a cross-validated correlation of 0.74 (se=0.011). Nitrate-nitrogen was the best predictor, followed by flow variability, air temperature and native riparian cover.



Predicting %EPT-abundance from the national SOE dataset

This exploration had a cross-validated correlation of 0.68 (se=0.012). Nitrate-nitrogen was the best predictor, followed by January air temperature, flow variability and DRP.



Conclusion: All macroinvertebrate metrics were well predicted by the BRT models, with nitrate-nitrogen being the most influential factor in predicting all metrics. Flow variability, native riparian cover and summer temperature were also consistently among the next most influential predictors.

Document 28

Jennifer Price

From: Ton Snelder <ton@landwaterpeople.co.nz>
Sent: Friday, 12 April 2019 5:15 AM
To: Jennifer Price
Subject: [redacted] new analysis
Attachments: PredictMCIUsingRF.docx

Follow Up Flag: Follow up
Flag Status: Flagged

Hi Jen,

I cannot replicate [redacted] results using randomForest models (see my results attached). Random forests are a very similar machine learning approach to BRT.
That is quite strange. My results are consistent with many studies over the past 10 years.

In any case, this sort of analysis is uninformative for two reasons:

1. It is a global (i.e., all sites at once) analysis that does not tell us if the response of MCI to DIN/DRP is spatially variable.
2. It does not tell us what the causative variables are or the extent to which DIN/DRP are acting as correlates to an underlying causative variable.

Feel free to use, or not, this additional bit of evidence.

Ton Snelder
____
Email: ton@lwp.nz
Phone: [redacted] | **Mobile:** [redacted]
Web: http://landwaterpeople.co.nz
Physical: Unit 13, 212 Antigua Street, Christchurch, New Zealand
Postal: P.O. Box 70, Lyttelton 8841, New Zealand

Predict the regional council + NRWQN MCI scores using Random Forest models (= very similar approach to BRT but with fewer subjective decisions such as learning rate).

First model without including usPasture ([redacted] excluded this obvious predictor for some reason). Second model includes usPasture. Both models include DIN and DRP as predictors.

First model had cross validated r^2 of 63%. Second model had cross validated r^2 of 63%.

Partial plots illustrate the model by showing the response of MCI to each predictor when all other variables in the model are held at their mean value. The value in parentheses after predictor label on x-axis is the predictor's importance in the model. The importance measure reflects the predictors contribution to model accuracy. Note that the predictor panels are arranged top left to bottom right in order of importance.

Figure 1. Partial plots for model that excluded usPastoral.

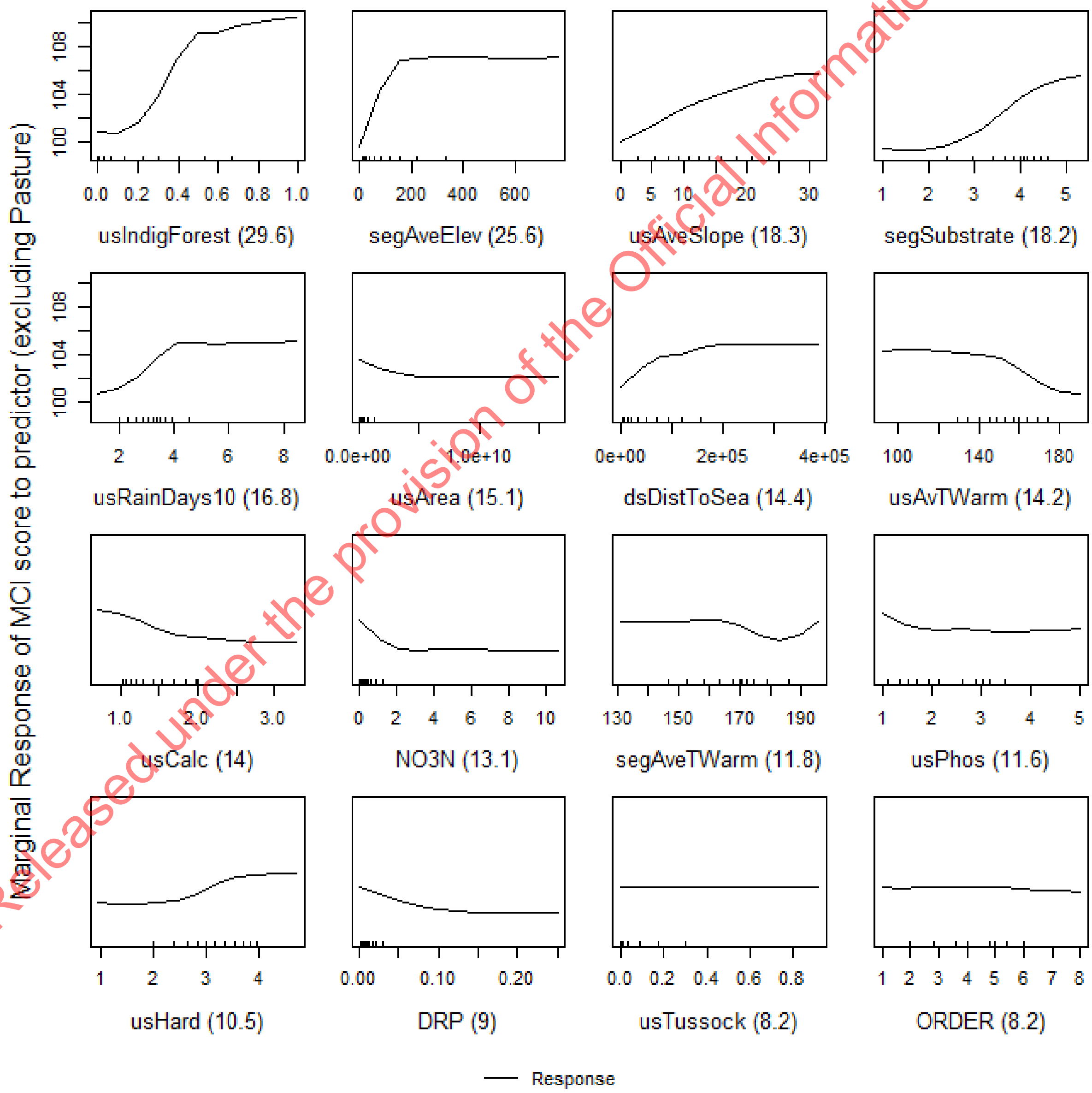
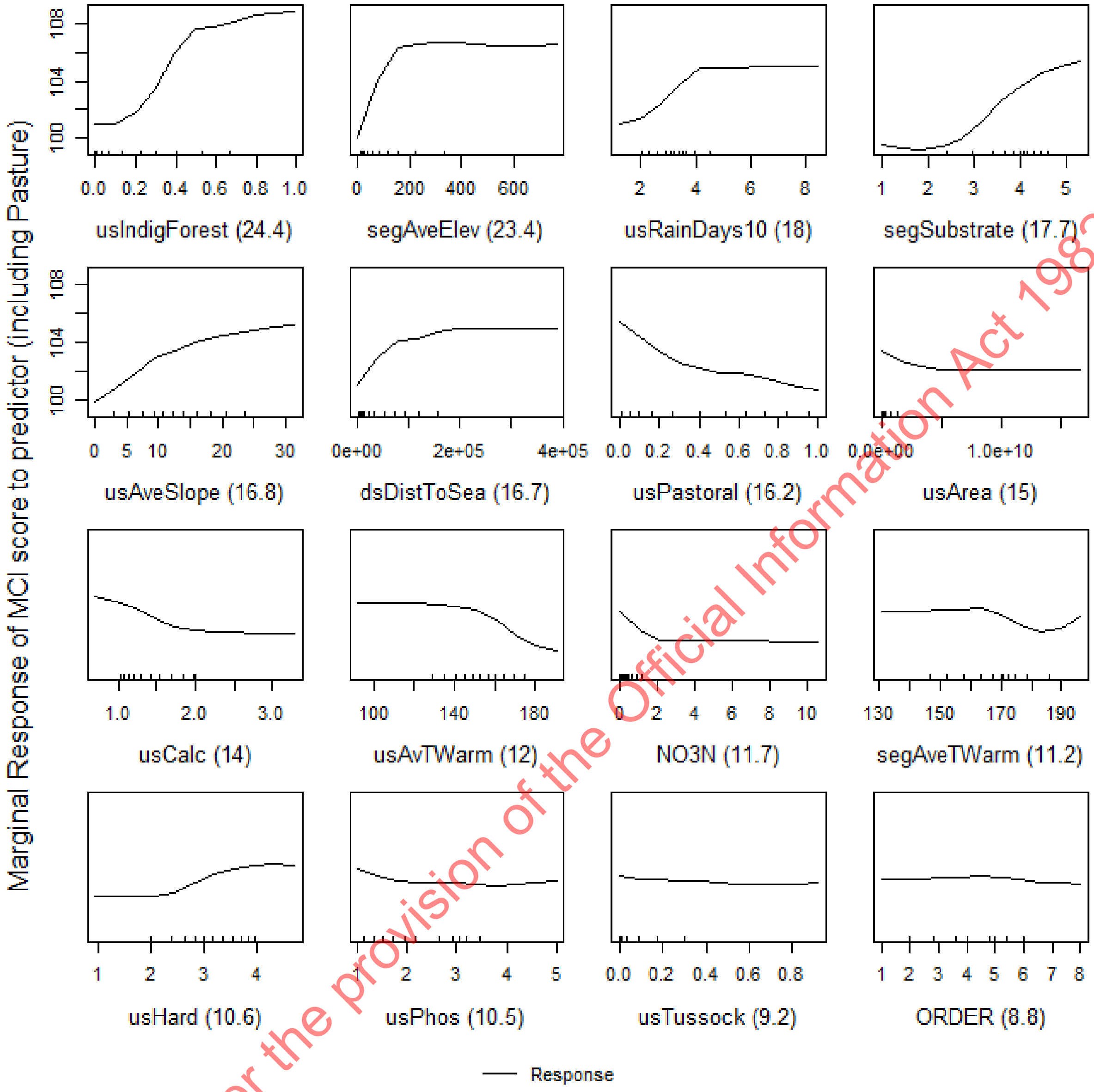


Figure 2. Partial plots for model that included usPastoral.



Jennifer Price

From: [redacted]
Sent: Wednesday, 8 May 2019 11:10 AM
To: Jennifer Price; Taylor, Ken
Subject: Your query about nutrient narrative sub-group correspondence

Follow Up Flag: Follow up
Flag Status: Flagged

Hi Jennifer (cc Ken)

Below I have quoted from the correspondence between the sub-group ([redacted]) that relates to a possible option of 'adjusting the bottom line for Nitrate N from 0.88 to 1.0' to allow for the fact that the bottom of the NOF A-Band for Nitrate toxicity ("High conservation value system. Unlikely to be effects even on sensitive species") is 1.0 mg/L NO_3-N.

At the end of this correspondence it seems to me that there is reasonable support for a discussion on whether to increase the bottom line from 0.88 to 1.0. The results of such a discussion could be either:

1. an agreement to alter the table and the STAG submits an altered table with 1.0 as the bottom line OR

2. A alternative table be provided from the STAG to the leaders group as second option based on [redacted] comment: "a shift from 0.88 – 1.0 would be a policy consideration potentially based on pragmatism".

I will let you read the material below and decide where to go from here. I hope this helps.

Regards

[redacted]

PS: quotes from email correspondence between the sub-group relating to [redacted] statement follow:

[redacted] original statement: "It would be a minor adjustment to make the bottom line 1.0 mg/L for median DIN and 1.5 mg/L for 95th percentile DIN, if we wanted to recognise the legal standing the current toxicity guidelines already have, in support of this new table. For the median DIN at least, the difference between 0.88 and 1.0 is almost within the analytical error (usually <=10%), so practically speaking this is not a significant change. However, does it change our confidence in the numbers?"

[redacted] – "I've had a look at the toxicity evidence for the A-band and it isn't particularly strong, so I support retaining the numbers as they are and keeping the narrative statement about the numerics also providing for nitrate toxicity."

[redacted] -

- "Your C and D bands refer to Nitrate Toxicity. I support this wording because 0.89 mg/L is getting toward the boundary of 1.0 that affords 99% species protection reported by Hickey 2013 and that are reflected in the current NOF toxicity table.
- The most recent ANZG report (*Default Guideline Values for Toxicants: Nitrate – Freshwater*) proposes the Default Guideline Value for "High conservation value systems (99% species protection)" as 1.1 mg/L NO3-N. Thus, it seems to me that your email suggestion of using the current Nitrate Toxicity Attribute Band A boundary of 1.0 mg/l as an ecosystem bottom line (C/D boundary) would be defensible and supportable as it is already acknowledged in the NPS-FM with the narrative "High conservation value system. Unlikely to be effects even on sensitive species". I would support a change to the bottom line from 0.89 to 1.0 if we are going to discuss this further. The other numbers for the A and B bands would be based entirely on the Weight of Evidence approach as discussed at the STAG- that I am not quite as familiar with."

[redacted] – "I recall the last two meetings discussing the option of using the existing nitrate A band as the bottom-line but there wasn't wide support, rather that the protection against nitrate toxicity could incorporated into the narratives (as [redacted] has done here). I'm not saying shifting the bottom-line to A of existing is a bad idea, it would need more discussion and wider support first though, just clarifying that the numbers here are those STAG asked for at the last meeting".

[redacted] - "In regard to the change from 0.88 to 1.0 I think that would need to be discussed further at the broader STAG group. My thinking is more consistent with [redacted] (toxicity approach and ecosystem health approach are different, even though toxicity would be considered within the ecosystem health context, so we should honour the methodological approach separatism from a science basis but a shift from 0.88 to 1.0 would be a policy consideration potentially based on pragmatism)".

[redacted] – "I agree with [redacted] – quote: "a shift from 0.88 – 1.0 would be a policy consideration potentially based on pragmatism". That is exactly why I think it is worth considering." It is scientifically defensible and more pragmatic if there is 'push-back' against the proposed NO3-N Table (which I suspect there probably will be). I am only requesting we keep this open as an option as [redacted] suggested."

Subsequent to the sub -group discussion [redacted] sent us all an email with the following comment:

[redacted] – "Ton Snelders analysis shows the periphyton attribute is likely to apply in the order of 55 to 65% of the nations rivers, and his numbers indicate the SIN and DRP concentrations that will be associated with that. The new ecosystem health table is essential for the balance of rivers around 40% and some where the periphyton attribute recommendations exceed the new ecosystem health table. In simple terms it seeks to apply in the areas where the current nitrate toxicity attribute currently applies and is a replacement table. The nitrate toxicity attribute is built on sound science, likely peer reviewed. Some have questioned this as its lab based. My view is that the nitrate toxicity science provides a much more scientifically credible way to set limits for ecosystem health, as it has a mechanism for the attribute influencing ecosystem health outcomes (nitrate toxicity). My suggestion to the group is that if a nitrate attribute for ecosystem health is desired, the nitrate toxicity table as it stands is a credible option and the value judgement is what level of species protection to provide for. The current level, bottom of the B band or bottom of the A band present some options for debate, clearly there are other options. This approach has in my opinion uses robust science and rationale for the policy change"

[redacted]

9(2)(g)(i) [redacted]

From: Jennifer Price <Jennifer.Price@mfe.govt.nz>
Sent: Wednesday, 8 May 2019 9:36 AM
To: 9(2)(g)(i) [redacted] Taylor, Ken <Ken.Taylor@agresearch.co.nz>
Subject: RE: Proposed narratives for nutrient tables

Hi 9(2) [redacted],
I am not sure if I have a record of the discussion – was this the discussion referred to by 9(2)(g) [redacted] below? I was not included in those emails.
Cheers
Jen

From: 9(2)(g)(i) [redacted]
Sent: Tuesday, 7 May 2019 4:56 PM
To: Taylor, Ken <Ken.Taylor@agresearch.co.nz>
Cc: Jennifer Price <Jennifer.Price@mfe.govt.nz>
Subject: Fw: Proposed narratives for nutrient tables

Dear 9(2)(g) [redacted] (cc Jennifer)

I was somewhat alarmed to see that the informed discussion we have had in the sub-group regarding an alternative option of changing the bottom line for Nitrate-N to 1.0 mg/L to align with the NOF A-Band has not been circulated to the STAG.

I sincerely hope that that option will be introduced to the STAG at some ssearly tage. Perhaps you can think about the best way to do this as I firmly believe it is the most pragmatic approach.

regards

9(2) [redacted]

9(2)(g)(i) [redacted]

From: Jennifer Price <Jennifer.Price@mfe.govt.nz>
Sent: Tuesday, 7 May 2019 3:25 p.m.
To: acanning (acanning@fishandgame.org.nz); Bryce Cooper; Chris Daughney; clarksonb (ClarksonB@landcareresearch.co.nz); Clive Howard-Williams; d.hikuroa (d.hikuroa@auckland.ac.nz); Graham Sevicke-Jones (Sevicke-JonesG@landcareresearch.co.nz); ian.hawes (ian.hawes@waikato.ac.nz); Jamie Ataria; Jenny Webster-Brown (jenny.webster-brown@canterbury.ac.nz); Joanne Clapcott (cawthron.org.nz); Jon Roygard (jon.roygard@horizons.govt.nz); ken.taylor@agresearch.co.nz; Mahinaarangi Baker; Dr Marc Schallenberg; Maria Burgess; Dr Mike Joy (vuw.ac.nz); Parish, Sarah (Sarah.Parish@agresearch.co.nz); R.G.Death (R.G.Death@massey.ac.nz); Ra (Ra@kahungunuwairarapa.iwi.nz); Tanira Kingi
Cc: Adrian Young; Alice Jacobs; Carl Howarth; Claire Conwell; Helli Ward; Isaac Bain; Jo Burton; Kirsten Forsyth; Lucy Bolton; Nik Andic; Oscar Montes de Oca Munguia; Stephen Fragaszy; Ton Snelder (landwaterpeople.co.nz); Vicki Addison
Subject: FW: Proposed narratives for nutrient tables

Kia ora koutou, please see below (and attached) further work on narratives for nutrient tables.
Ngā mihi
Jen

From: 9(2)(g)(i) [redacted]
Sent: Tuesday, 7 May 2019 3:15 PM
To: Jennifer Price <Jennifer.Price@mfe.govt.nz>
Cc: 9(2)(g)(i) [redacted]
Ken.taylor@agresearch.co.nz
Subject: Proposed narratives for nutrient tables

Dear Jen

We 9(2)(g)(i) [redacted] have broad agreement on the narrative wording attached … I am aware that there are lingering concerns about the numbers themselves and we would like to see more discussion around whether trophic and toxicity considerations should be combined in a single attribute table, and the justification for this.

Could you please circulate the attached nutrient tables and comments below to the whole STAG group please?
Thanks
9 [redacted] (

Please find attached an attempt at a narrative for the nutrient tables that is;

- consistent with the narratives used for other attribute tables

- reflects our nervousness around implying that a particular DIN level will necessarily lead to eutrophication

- reflects the NBL's protection with respect to nitrate toxicity

Also note …

- There is a place holder re Groundwater (footnote 1 for DIN attribute table) while we wait for Chris Daughney to comment further.

- It would be a minor adjustment to make the bottom line 1.0 mg/L for median DIN and 1.5 mg/L for 95th percentile DIN, if we wanted to recognise the legal standing the current toxicity guidelines already have, in support of this new table. For the median DIN at least, the difference between 0.88 and 1.0 is almost within the analytical error (usually <=10%), so practically speaking this is not a significant change. However, does it change our confidence in the numbers?

Cheers

9(2) [redacted]

9(2)(g)(i) [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

****

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Document 33

Jennifer Price

From:	Jennifer Price
Sent:	Wednesday, 22 May 2019 2:33 PM
To:	David Hamilton (david.p.hamilton@griffith.edu.au)
Subject:	FW: STAG nutrients and ecosystem health discussion
Attachments:	STAG views on nutrient numbers combined.docx

Hi David,
Here is the final piece of information I was wanting to send you on the STAG nutrient discussions.
Please let me know if anything is unclear or if you'd like further information on anything.
Kind regards
Jen

From: Taylor, Ken <Ken.Taylor@agresearch.co.nz>
Sent: Wednesday, 22 May 2019 2:25 PM
To: acanning@fishandgame.org.nz; 'r.g.death@massey.ac.nz' (r.g.death@massey.ac.nz) <r.g.death@massey.ac.nz>; Dr Mike Joy (vuw.ac.nz) <mike.joy@vuw.ac.nz>; Ra@kahungunuwairarapa.iwi.nz; Dr Marc Schallenberg <marc.schallenberg@otago.ac.nz>; Joanne Clapcott (cawthron.org.nz) <Joanne.Clapcott@cawthron.org.nz>; ClarksonB@landcareresearch.co.nz; Chris Daughney <Chris.Daughney@mfe.govt.nz>; Clive Howard-Williams (niwa.co.nz) <clive.howard-williams@niwa.co.nz>; Sevicke-JonesG@landcareresearch.co.nz; Bryce.Cooper@niwa.co.nz; ian.hawes@waikato.ac.nz; Jenny Webster-Brown <jenny.webster-brown@canterbury.ac.nz>; jon.roygard@horizons.govt.nz; Mahina-a-rangi Baker
9(2)(a) [redacted]; Tanira Kingi <tanira.kingi@scionresearch.com>; Jamie.Ataria@lincoln.ac.nz; d.hikuroa@auckland.ac.nz
Cc: Jennifer Price <Jennifer.Price@mfe.govt.nz>; Martin Workman <martin.workman@mfe.govt.nz>; Lucy Bolton <Lucy.Bolton@mfe.govt.nz>; Jo Burton <Jo.Burton@mfe.govt.nz>
Subject: nutrients and ecosystem health discussion

Kia ora koutou

Thanks all of you for participating in this exercise, the purpose of which was primarily to establish levels of agreement around various points of discussion that we have been wrestling with over the past few weeks. I appreciate your contributions in this regard. Thanks also to those of you who provided me with very detailed footnotes by way of qualifications, caveats and disclaimers. These will be very useful in preparing our report.

All I have done at this stage is to combine your responses into a single table, which I have attached. Some overall observations:

- There is very strong (although not unanimous) support for the concept of setting thresholds for nutrients for ecosystem health protection
- With respect to nitrogen, there is very strong support for a single set of numbers for nitrogen – less so for phosphorus - there, views are equally divided on whether spatial variation should be handled via separate tables or an exceptions regime
- The weight of evidence approach is supported by a good majority (9/14), but a number of you are still to be convinced.
- There is very strong support for including reference to N toxicity in the narrative that sits behind the numbers but very little support for adjusting the bottom line number to align with a toxicity threshold

From a policy advice point of view, one important conclusion I would draw from this is that while there is still some contention as to the method by which ecosystem health thresholds are to be defined, there is very good agreement about (broadly) where the bottom line should be drawn. On that basis I believe that not only should we seek to resolve the differing perspectives but that there is a good prospect that we can get much closer to full agreement before the government's consultation process starts

Outstanding matters that still need serious technical input relate to metrics and sampling methods/compliance definitions. We need to put the DIN v NO3-N debate to bed, and we need to provide sound advice on statistics (medians, percentiles, maxima etc) and sampling frequency.

Ngā mihi
Ken

Ken Taylor - Director
Our Land and Water National Science Challenge
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W: www.ourlandandwater.nz

OUR LAND AND WATER Toitū te Whenua, Toiora te Wai National SCIENCE Challenges

Document 33 - attachment

STAG member	I agree that having a single set of numbers for nitrogen for ecosystem health (EH) protection is a useful approach	I support the "weight of evidence" method for deriving the N numbers	I support the narrative for EH including reference to eutrophication	I think it is useful to include reference to toxicity in the narrative for EH to add further weight to the evidence base for the bottom line (as in [redacted] drafting)	I support minor wording changes to the narrative as suggested by [redacted]	I support Shifting the "bottom line" of the N table from 0.88 mg/l to a toxicity threshold (e.g., bottom of the A band in the current N toxicity table) to supplement the "weight of evidence" justification	I support Shifting the "bottom line" of the N table from 0.88 mg/l to a toxicity threshold because it is a more defendable number	I think it is necessary to set ecosystem health thresholds for phosphorus (DRP)	DRP thresholds (including the bottom line) should be differentiated spatially (e.g., North Island v South Island, or some other classification system)	Response received
[redacted]	Agree	Agree	Agree	Agree		Disagree	Disagree	Agree	Disagree	Y
[redacted]	Agree	Agree		Agree	Agree	Abstain	Abstain	Agree	Agree	Y
[redacted]	Agree	Science is unresolved	Disagree	Agree	Disagree	Disagree	Disagree	Agree	Disagree	Y
[redacted]	Agree	Science is unresolved	NA	Agree	NA	NA	Agree	Science is unresolved	Agree, if science supports P table for EH	Y
[redacted]	Agree	Science is unresolved	Agree	Agree	Disagree	Agree	Agree	Agree	Agree	Y
[redacted]	Agree	Agree	Disagree	Agree		Disagree	Disagree	Agree	Disagree	Y
[redacted]	Agree	Science is unresolved	Disagree	Agree		Disagree	Disagree	Agree	Science is unresolved	Y
[redacted]	Agree	Agree	Disagree	Agree	Agree	Agree		Agree	Disagree	Y

[redacted] 9(2)(g)	Agree	Agree	Agree	Agree	Agree	Disagree	Disagree	Agree	Disagree (prefer exceptions)	Y
[redacted] 9(2)	Disagree[10]	Science is unresolved [2, 11]	Disagree	Agree[12]	Disagree[12]	Disagree[13]	Agree[14]	Agree[15]	Agree[16]	Y
[redacted] 9(2) ( )(i)	Agree	Agree	Disagree	Agree but only to the D band narrative	Disagree because of reference to eutrophication	Disagree	Disagree	Agree	Agree	Y
[redacted] 9(2)	Agree	Agree	Agree	Agree	Agree	Disagree	Disagree	Disagree		Y
[redacted] 9((i)	Agree	Agree	Agree	Agree	Agree	Disagree	Disagree	Agree		
[redacted] 9(2)(g)	Agree	Agree	Agree	Agree		Disagree	Disagree	Agree		
Agree	13	9	6	14	6	2	3	12	5	
Disagree	1		6		4	10	9	1	5	
Unresoled		5						1	1	
Not able to comment						1	1			

[redacted] 9(2)(g) *footnotes*

Column 3: I am not entirely convinced of the weight of evidence approach particularly as this includes periphyton which are already covered by the Periphyton attribute

Column 6: Disagree - there will be separate Attributes for Wetlands at some stage. Here we are talking about rivers.

Column 7: Agree - my suggestion is to provide this as a second option because of my uncertainty over the Weight of Evidence approach

Column 8: Agree - while recognising that 0.88 will be even more protective than the toxicity A-Ban. However, my concern is about pragmatism and the fact that nitrate toxicity is already accepted in the NPS and hence is more defendable as a bottom line that offers '99% species protection'.

[redacted] *footnotes*

[1] And I think that should be DIN

[2] We have been given two conflicting analyses: one from [redacted] *and one from Ton and there has been no resolution on those or if it's important to have resolution. There has also been no resolution on the attribute statistic and sampling period. We need an exceptions footnote, like that required for DRP. There are streams that I am aware of where natural geothermal input of DIN leads to concentrations in excess of the proposed bottom line – we should acknowledge this possibility with an exceptions footnote.*

[3] The set concentration bands and the wide range in reference condition suggest words such as minor or moderate elevation above natural reference conditions will often be inaccurate (see [redacted] *DRP plots). We need a better way of expressing this.*

[4] And this would make the nitrate toxicity table redundant

[5] Disagree – see note 3.

[6] This is an attribute for ecosystem health so we need to justify it on the weight-of-evidence approach for EH but note that this covers off nitrate toxicity as well; i.e., makes it redundant as bottom line requires lower concentration than A band threshold of nitrate toxicity table.

[7] I don't think this is a valid rationale even if it was true – see note 6

[8] Whilst acknowledging the 'internal loading' mechanism for P supply to rivers, I don't think this invalidates the DRP attribute.

[9] I prefer a single bottom line with an exceptions footnote acknowledging that some rivers, particularly some of those in certain river classes, will exceed these naturally. For me the 'extra noise' around a 'productive class' which still results in a bunch of exceptions is simply not worth it – the wide variation in the DRP plots Adam did convinces me that all those exceptions are best handled on a bespoke basis.

[redacted] *footnotes*

My view is there should be four controls for nutrient impacts on ecosystem health based on the mechanisms that nutrients impact on ecosystem health. This is to enable these to be applied in an effects based manner, customisable to catchments. Three types of control are as in the NPS-FM now i.e. the ammonia toxicity table, the periphyton attribute (and associated notes) and the nitrate toxicity attribute. It is recommended that each of these be amended from their current form in the NPS-FM. Each of these has clear, peer reviewed science to inform policy and an established mechanism/rationale by which setting limits *in policy provide protection for ecosystem health. In my view, the level of toxicity allowed for as the national bottom line is a policy call. The science is clear about what percentages of species protection is provided for at differing concentrations. Lowering the concentration that is the national bottom line for toxicity is a potential way to strengthen protection for ecosystem health with a clear set of evidence to back up the setting of the thresholds. The forth control is consideration of downstream nutrient sensitive environments. In my view, the ammonia attribute and nitrate toxicity attribute require amendment to provide a similar note or policy around accounting for sensitive downstream environments as is provided in the periphyton attribute. Further the periphyton attribute should keep this consideration of downstream environments with its requirements to set both DIN and DRP limits for periphyton growth. A potential national attribute table for concentrations of DIN and DRP to provide for periphyton outcomes has been presented to the STAG, as has science that shows regional models of such tables perform better that the national table. The STAG therefore decided a national table of DIN/DRP limits for periphyton was not appropriate and the retention of the current provisions was the preference. Overall providing further clarity in the NPS-FM around setting nutrient limits for ecosystem health is recommended. For example to describe how to consider the ammonia toxicity, nitrate toxicity and periphyton requirements as well as those of downstream environments in a catchment or freshwater management unit. Elevating the guidance on setting nutrient limits from the footnotes of an attribute table to another part of the policy framework is potentially a start for this.*

[11]The science is unresolved. A request for a peer review of the science has been made as a part of the STAG and at this stage the current recommended bottom lines have not been through a formal peer review process. The weight of evidence approach as it is currently being advanced has provided a series of potential bottom line numbers to the STAG ranging from around 1.6 g/m^3 nitrate to less than 0.7 g/m^3 nitrate depending on how the math is completed. The wide ranging studies that inform the weight of evidence approach have a wide range of recommended bottom line numbers for different purposes and these are averaged to inform the recommended national bottom line in the proposed table. Further there is potential that the current pooling of studies is presenting a double accounting of sorts, whereby requirements for controls on nutrient impacts on ecosystem health due to impacts on periphyton are being used to inform the overall number, however controls for periphyton are not required in parts of the country. Science presented to the STAG by Ton Snelder shows approximately 55 to 65% of NZ requires nutrient controls to manage periphyton impacts on ecosystem health, and the remainder do not as periphyton is not an issue in these locations due to substrate type or some other reason. The mechanisms for impacts of nutrient on ecosystem health in the balance of NZ's rivers relate to toxicity effects or impacts on downstream environments. The proposed table based on the weight of evidence approach could therefore constrain nutrient concentrations in parts of NZ for no net gain in ecosystem health. It is also noted that the requirement to lower concentrations in catchments to the new proposed numbers would only apply where concentrations are currently above these numbers, as the maintain and improve provisions provide controls on raising in-river nitrate concentrations to higher concentrations. My view is that to strengthen protection of ecosystem health through nutrient controls, the impact on downstream environments should be added to the tables for nitrate and ammonia toxicity and the policy calls on the levels of protection for these tables be revisited. There is potential in areas to be managed for periphyton, that the new ecosystem health numbers in the proposed table provide lower concentrations than recommendations for periphyton. Although this is likely to be rare, it does raise a question as to why more stringent controls would be needed on an effects basis. It is recommended that consideration be given to ensuring the information required (monitoring and science) for setting the nutrient criteria for periphyton is being undertaken and resourced both nationally and regionally.

[12]Noting my view that the table should be about toxicity and potential eutrophication impacts of sensitive downstream environments.

[13]Support removing the weight of evidence approach from the table as the science is unresolved.

[14]Noting my view that the setting of the specific nitrate toxicity threshold for nitrate is a policy call on the degree of protection of species required. An equally valid approach from a science perspective would be to set the value for the national bottom line at the current break between the B and C band in the nitrate toxicity table. The policy decision required is what level of protection is desired. The available science on toxicity threshold impacts provides a strong basis for policy now and further investment in this type of science over time for more New Zealand species could be useful for future policy setting such as defining objectives in regional plans or future revision of the NPS-FM.

[15]Where DRP has mechanistic effects on ecosystem health e.g. in the areas where the periphyton requirements to set limits are required (approximately 55 to 65% of NZ) and in the balance of NZ where DRP is likely to impact on nutrient sensitive downstream environments.

[16]Research of drivers of periphyton growth shows that customised setting of DRP limits will be required to manage periphyton.

Document 34

Developing relationships between periphyton and environmental variables

Cathy Kilroy

STAG Meeting, MFE, 26 February 2019

Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

Periphyton: most primary production in most NZ rivers

- Periphyton peak biomass is logical measure of trophic state
- Responds to changes in nutrients – logical basis for DIN & DRP management

Themes

- Challenges in identifying robust periphyton – nutrient relationships in rivers

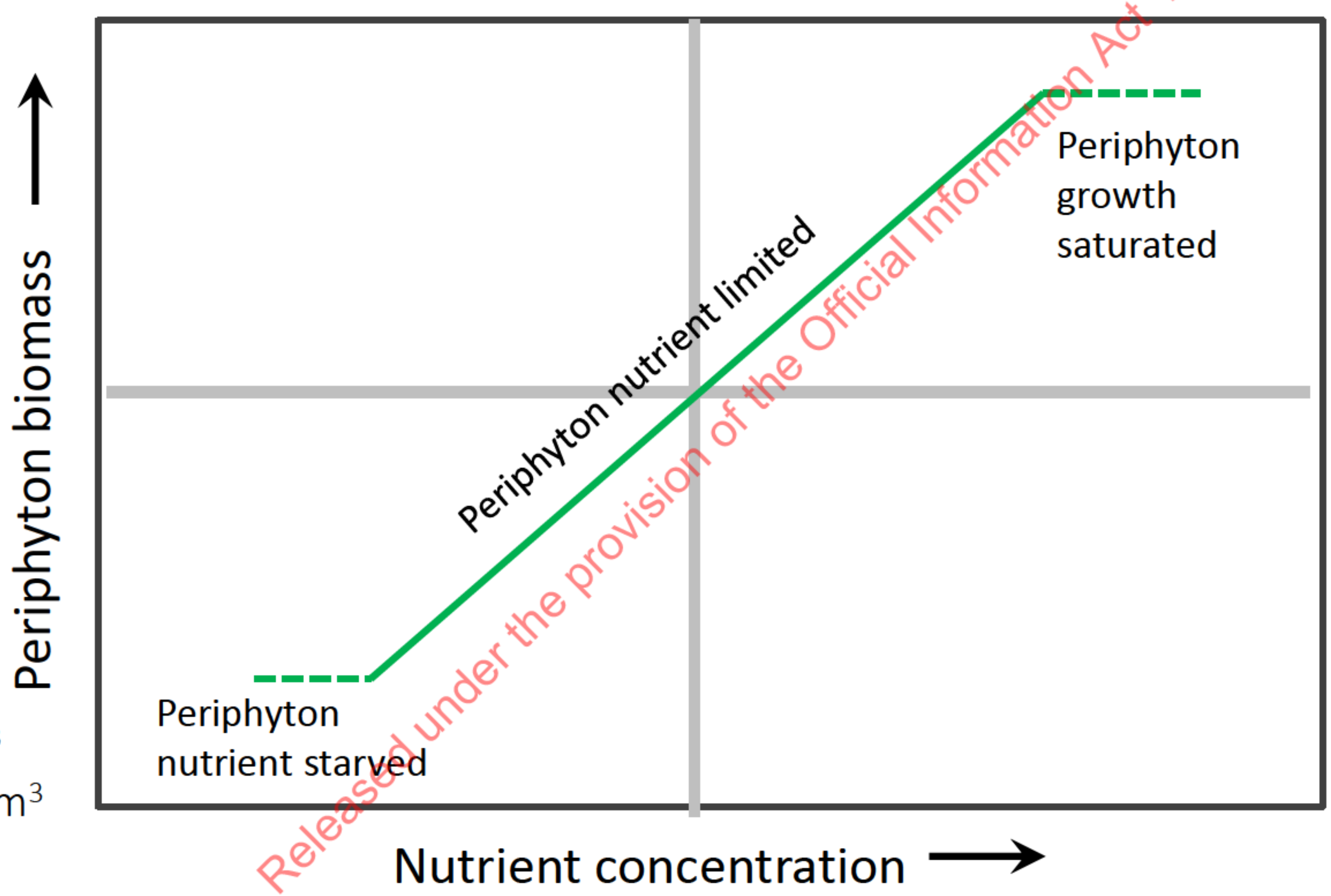
- General approach used by Biggs (2000)

- Development of new relationships using new data from regional councils: summary of outcomes, regional and national models (focussing on chlorophyll *a*)

- Next steps

Why are periphyton – nutrient relationships in rivers so difficult to pin down?

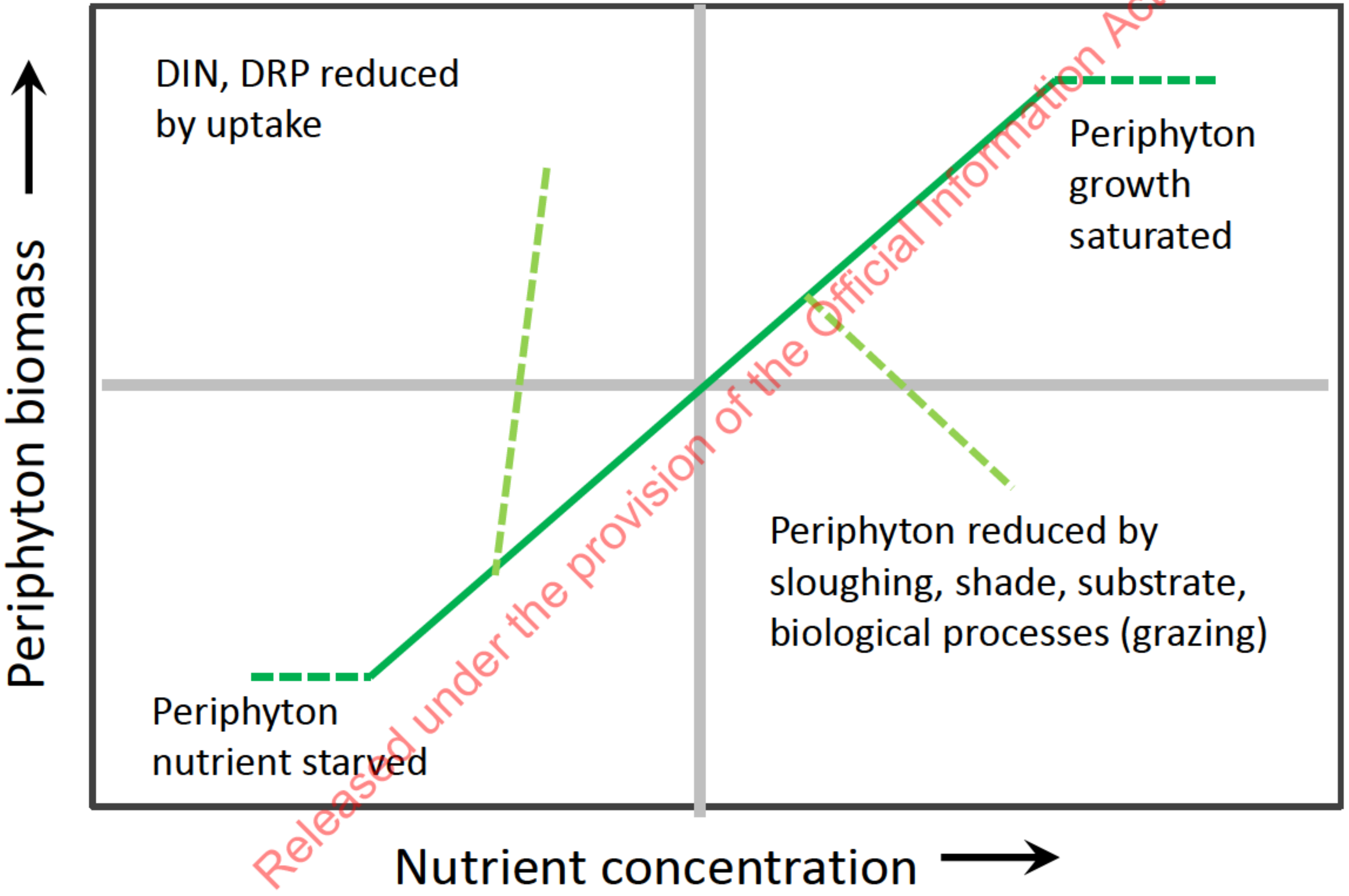
Periphyton vs. nutrients: idealised relationship



DIN ~100 – 400+ mg/m^3
DRP <1– 25 mg/m^3

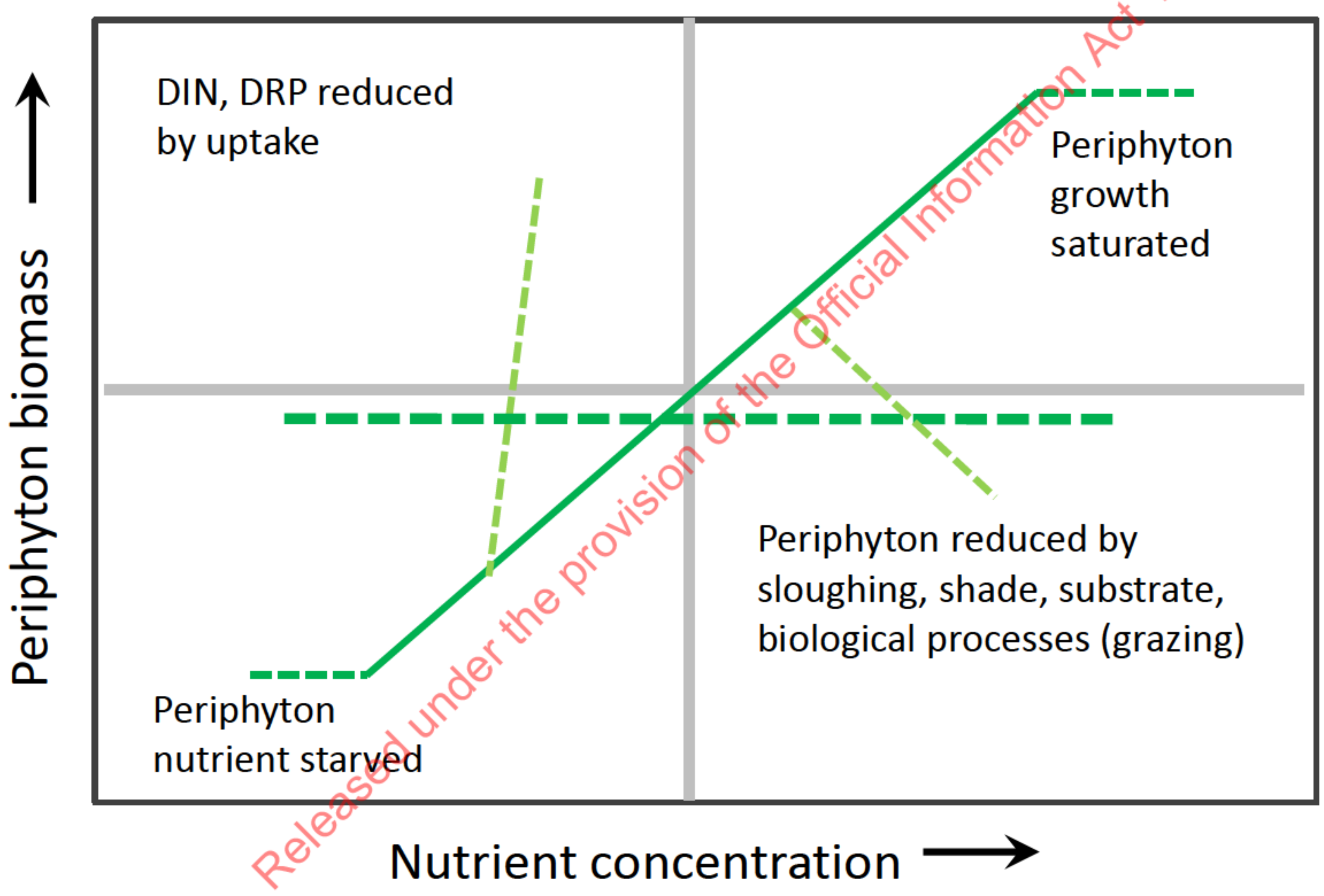
DIN <1? mg/m^3
DRP <?0.1 mg/m^3

Periphyton vs. nutrients in rivers: **between sites**



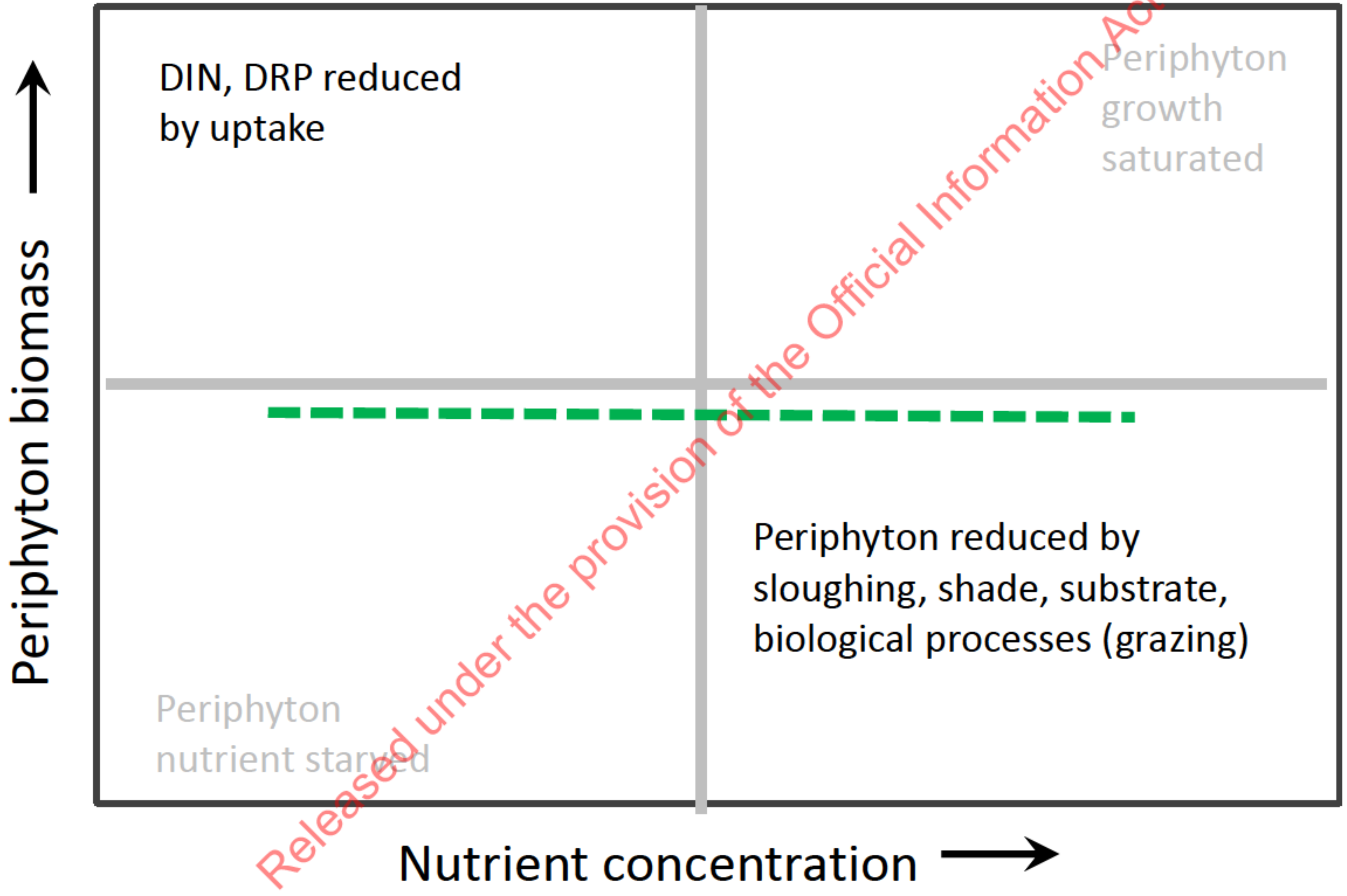
Expected patterns from synoptic surveys

Periphyton vs. nutrients in rivers: **between sites**



Expected patterns from synoptic surveys

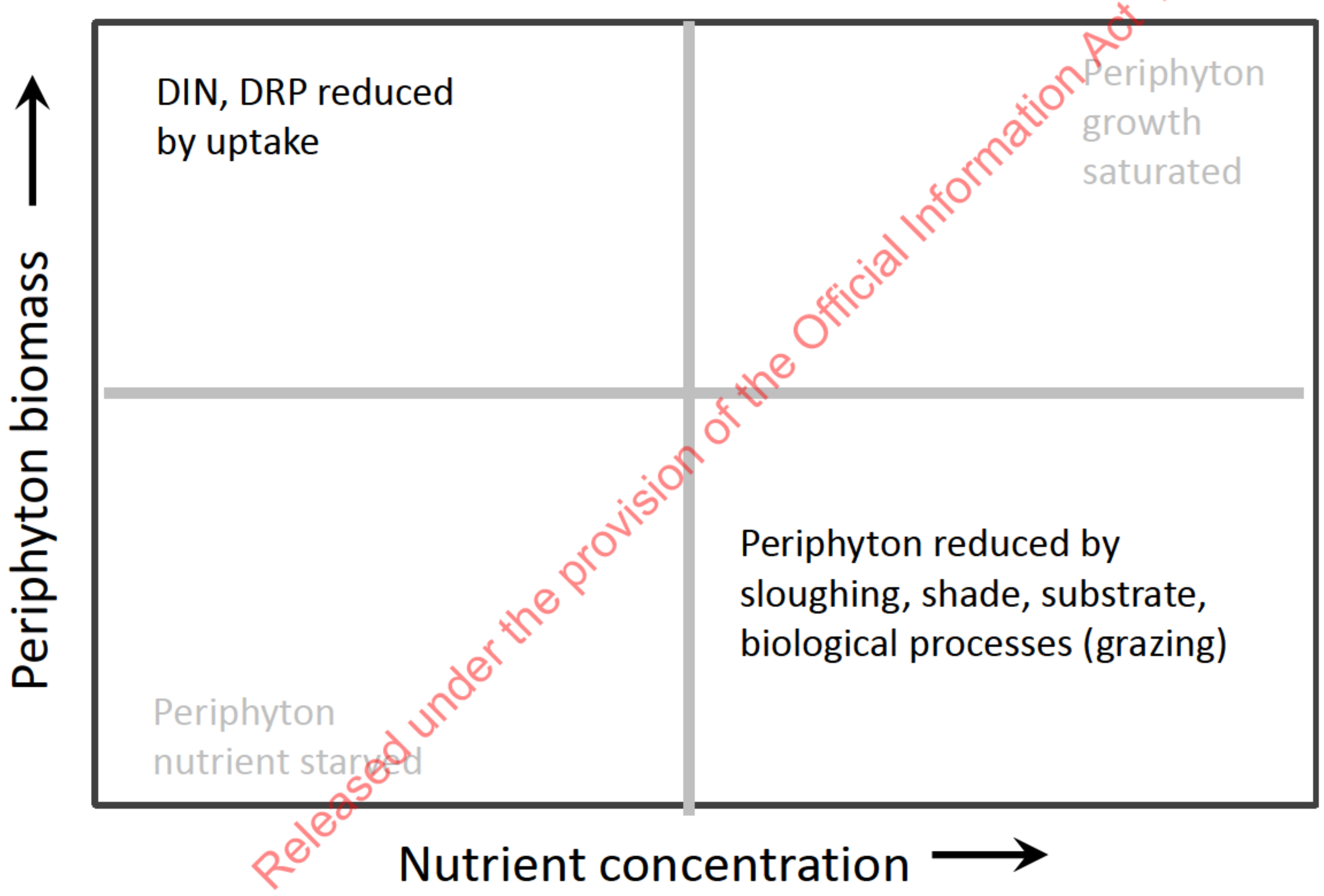
Periphyton vs. nutrients in rivers: **between sites**



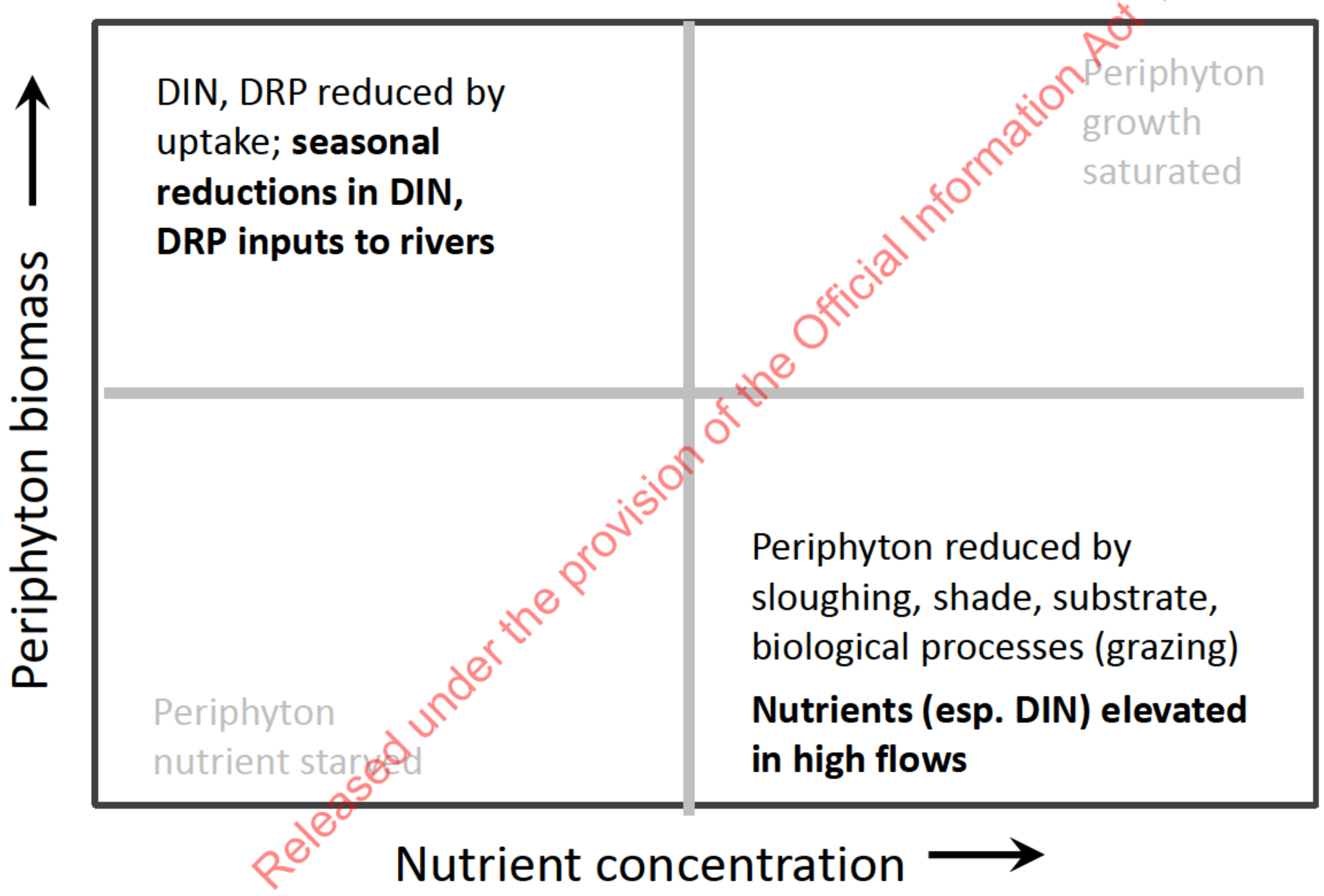
Expected patterns from synoptic surveys

Conceptual model adapted from Munn et al. (2010). *Environmental Management* 45: 603.

Periphyton vs. nutrients in rivers: **within sites?**

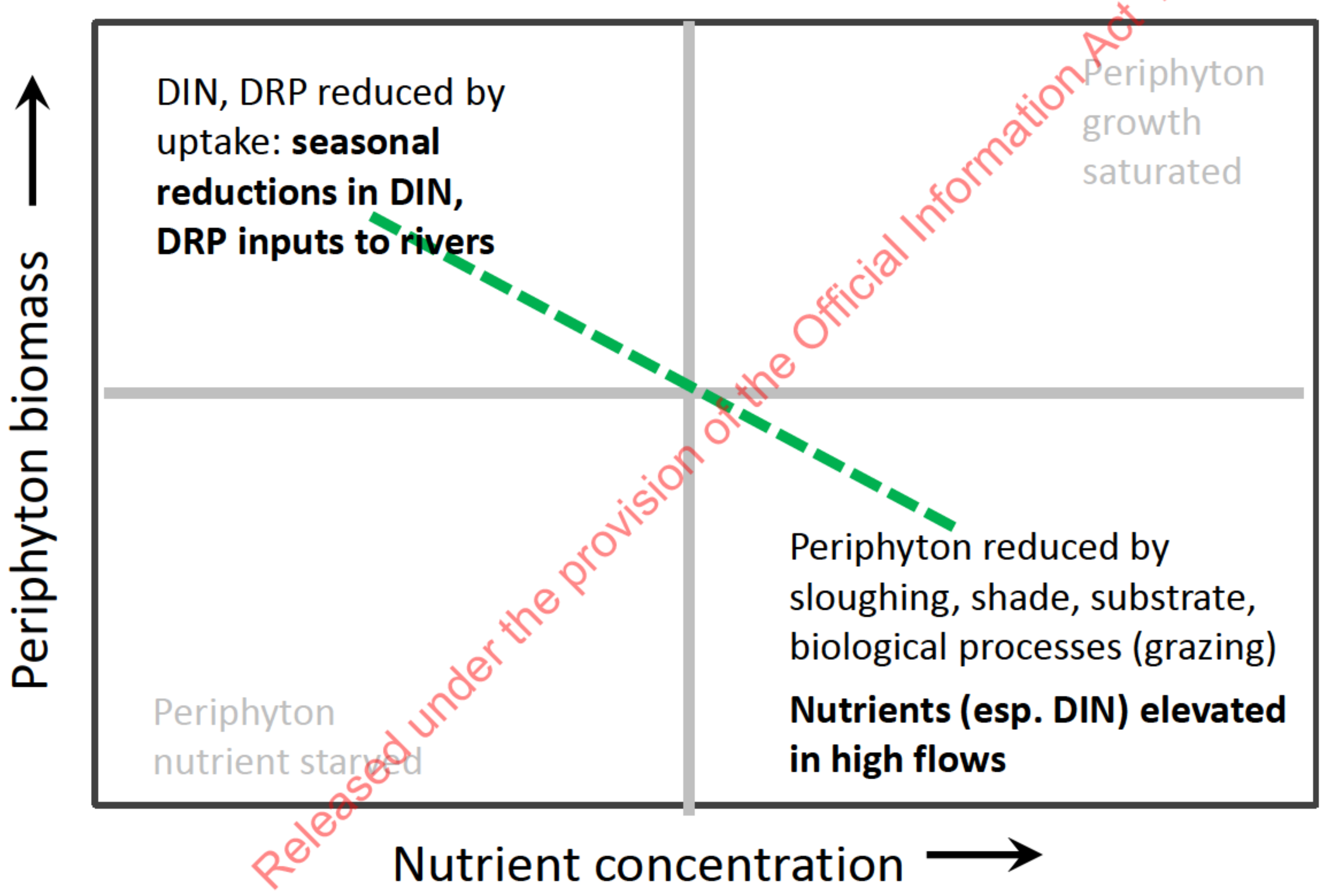


Periphyton vs. nutrients in rivers: **within sites**



Season and flow affect relationships from data collected over time

Periphyton vs. nutrients in rivers: within sites



Negative relationships are typical pattern in within-site relationships, esp. DIN

In summary:

- Periphyton biomass in rivers is influenced by multiple factors in addition to nutrients (flows, light, substrate, grazing, …)
- Periphyton itself can affect nutrient concentrations via uptake
- Nutrient concentrations also related to flows (nutrients are blunt tool)
- **Result**: rarely possible to find positive links between periphyton biomass and nutrients from synoptic surveys; negative relationships almost inevitable over time within sites.

The Biggs (2000) approach

The Biggs (2000) relationships

J. N. Am. Benthol. Soc., 2000, 19(1):17–31

Eutrophication of streams and rivers: dissolved nutrient-chlorophyll relationships for benthic algae

BARRY J. F. BIGGS[1]

National Institute of Water and Atmospheric Research Ltd, P.O. Box 8602, Christchurch, New Zealand

Abstract. Statistical models for predicting the effects on algal biomass of eutrophication are much better developed for lentic systems than for lotic systems, partly because of the dynamic physical nature of streams as controlled by flood regimes. I analyzed data from 30 sites in 25 runoff-fed streams and rivers to develop statistical models for mean monthly and maximum chlorophyll *a* as a function of soluble nutrient concentrations and days of accrual (reflecting the frequency of flood disturbance events). Variation in stream-water nutrients explained 12–22.6% of the variation in mean monthly chlorophyll *a* and 29.5–32.5% of the variation in maximum chlorophyll *a* among sites. Days of accrual explained 39.7% and 61.8 % of the variation in mean monthly and maximum chlorophyll *a*, respectively. Multiple regression models combining dissolved nutrient data and days of accrual explained 43.7–48.8% of the variation in mean monthly chlorophyll *a* and 72.1–74.1% of the variation in maximum chlorophyll *a* among sites. In streams with infrequent floods and long accrual periods (e.g., >100 d), a relatively small increase in dissolved nutrients greatly increased the frequency of high biomass events. However, as could be anticipated, this result did not occur in more flood-prone streams. A nomograph to predict oligo-, meso-, and eutrophic conditions as a function of nutrient concentrations and days of accrual is presented based on the regression models for maximum chlorophyll *a*. The models need further testing, but might be useful for predicting the effects of changes in nutrients on benthic algal biomass in other temperate streams and rivers. I suggest that variable nutrient criteria for the prevention of benthic algal proliferations could be set in streams in relation to regimes of local flood frequency and expected time available for biomass accrual. The present analysis suggests that managing nutrient supply could not only reduce the magnitude of maximum biomass, but also reduce the frequency and duration of benthic algal proliferations in streams.

Key words: stream ecology, eutrophication, enrichment, nutrients, nitrogen, phosphorus, flooding, disturbance, algae, periphyton, water resources management.

Simple regression models ($R^2 > 0.7$)

New Zealand Periphyton Guideline:

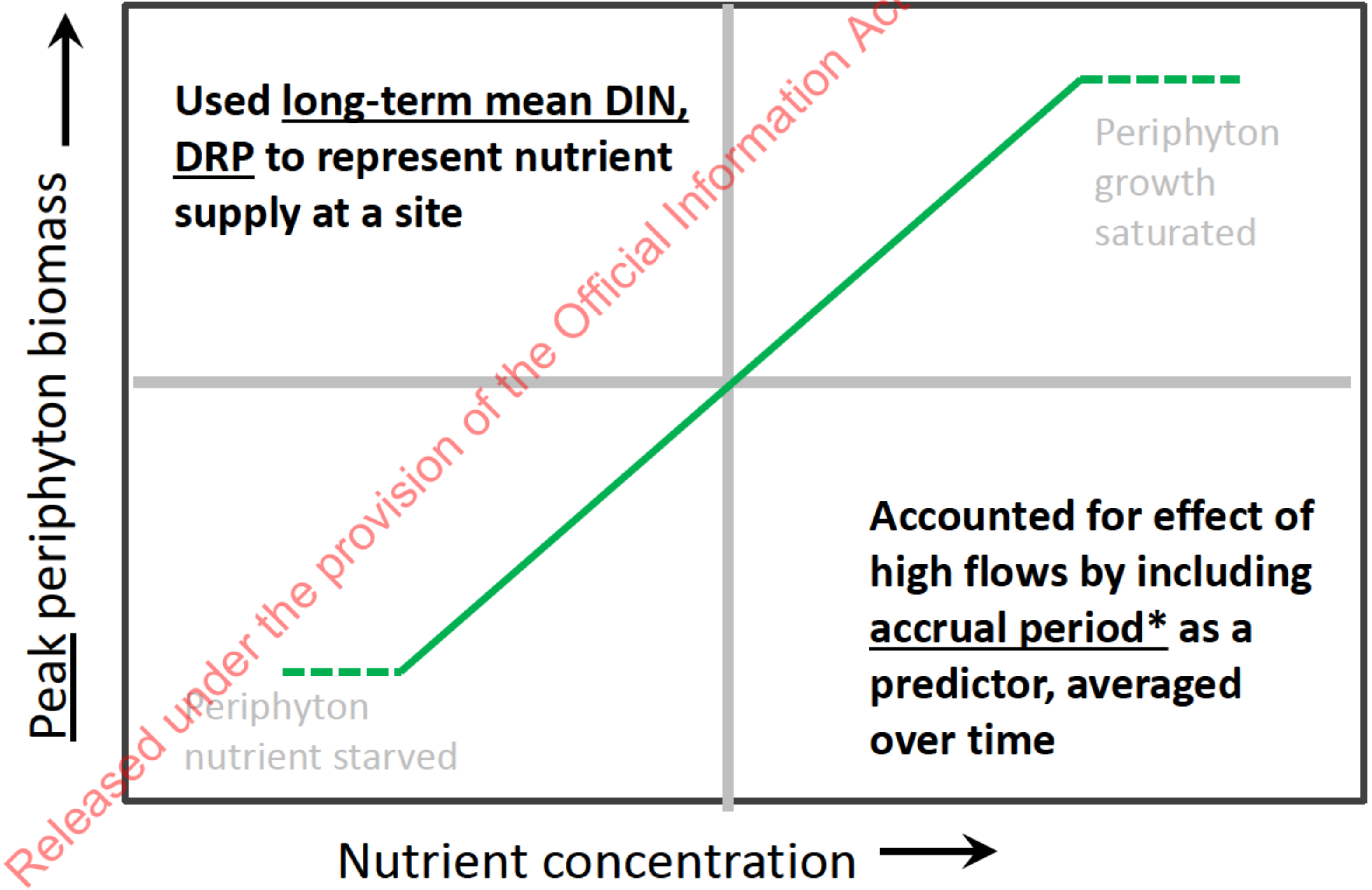
Detecting, Monitoring and Managing Enrichment of Streams

Soluble inorganic nitrogen (SIN = $NO_3 - N + NO_2 - N + NH_4 - N$) and soluble reactive phosphorus (SRP) concentrations (mg/m³) predicted to prevent maximum biomass from exceeding the given levels. The nutrient concentrations are to be determined as mean monthly concentrations over a year. Limits of detection are assumed to be around 5 mg/m³ for SIN and 1 mg/m³ for SRP if analyses are carried out using standard autoanalyser techniques. The chlorophyll a at 120 mg/m² refers to filamentous green algae dominated communities whereas the chlorophyll a at 200 mg/m² refers to diatom dominated communities. AFDM = ash-free dry weight.

Study	Chlorophyll *a* = 50		AFDM=35 Chlorophyll *a* = 120 Chlorophyll *a* = 200	
Days of accrual	SIN	SRP	SIN	SRP
20	<20	<1	<295	<26
30	<10	<1	<75	<6
40	<10	<1	<34	<2.8
50	<10	<1	<19	<1.7
75	<10	<1	<10	<1
100	<10	<1	<10	<1

Biggs (2000) solution to periphyton vs. nutrients problem

Predicted <u>maximum chlorophyll *a*</u> from monthly data over at least 12 months



* based on 3 x median flow

Shortcomings of the 2000 models

- Restricted to a single river type (hill-fed, snowmelt affected, unshaded, gravel-bed)
- Low range of DIN (maximum of 232 mg/m^3) – below saturation
- Tendency to over-predict chl *a* for given DIN and DRP

BUT models highlighted **sensitivity of chl *a* to low range of DIN** (chl *a* range < 10 to > 800 mg/m^2)

New periphyton – environment relationships using new data

Development of new models using new data

- New regional council data : e.g., Horizons started monthly periphyton surveys in 2008 (ongoing)
- Currently data from ECan (2011 – 2014), BOPRC (2015 –), GWRC (2016 –), ES (2014 –) [requirement of NPS]
- Site selection to cover range of nutrients and flow variability
- Periphyton as Chl *a*, %cover (maximum, 92nd percentile)
- Predictors: DIN, DRP, TN, TP, substrate, water temp., conductivity, etc. + river flow
- Used GLM (regression approach).

Development of new models using new data

New analyses to determine more accurate accrual periods at each site

Previous assumption that 3 x median adequately describes a flow magnitude that re-sets periphyton does not hold*

- Used monthly data to derive "effective flow" (EF) at each site
- calculated mean accrual period from EF (in multiples of median flow) [Variable: **DaEF** (days)]. EF from 1.5 to 15 x median.

*See Hoyle et al. (2017) Freshwater Biology 62(2): 258-273

Development of new models using new data

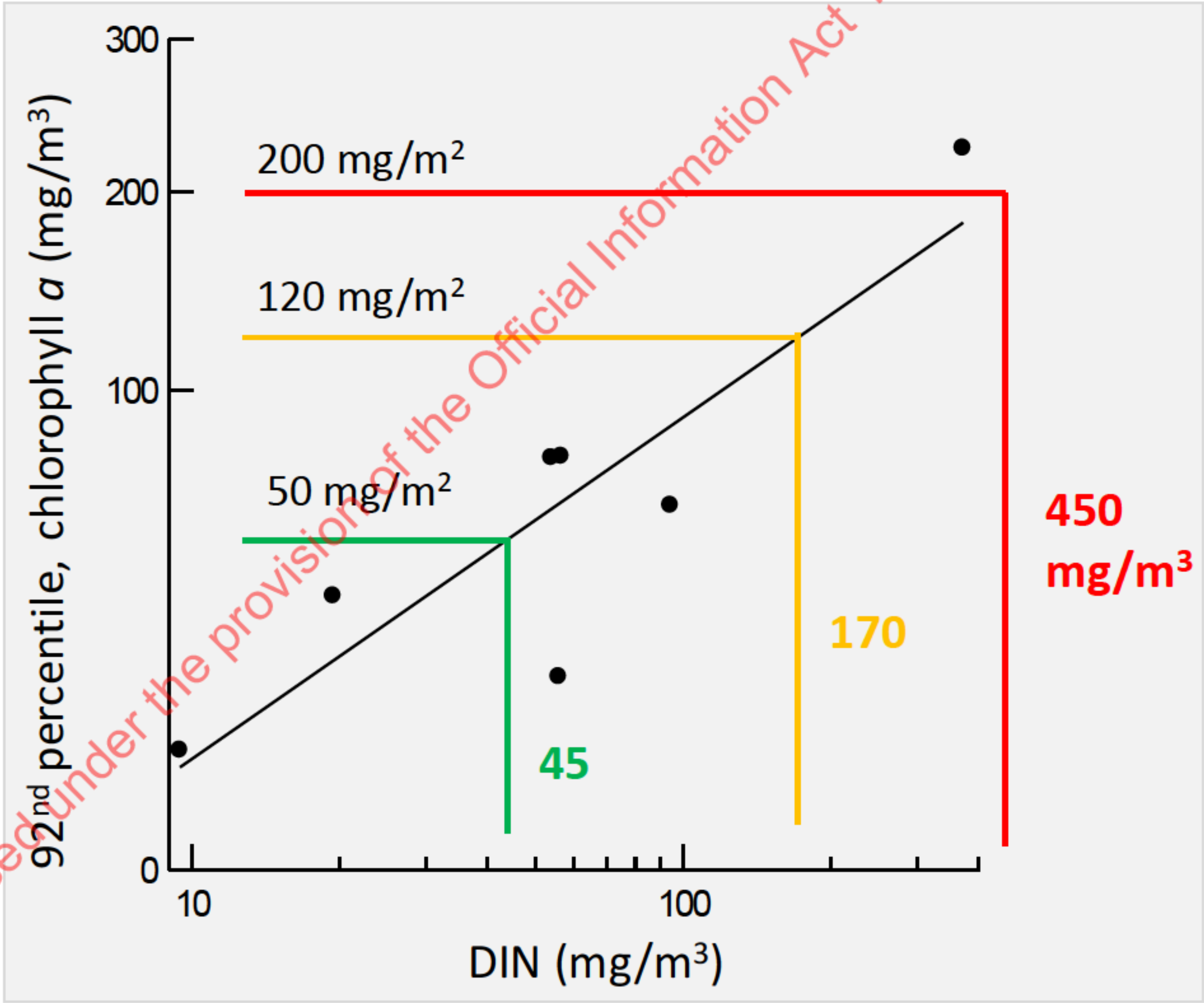
Example: ECan 3-y dataset, 24 sites in hill & alpine catchments

ECan 3-y dataset, 24 sites in hill & alpine catchments

At 7 alpine sites:

2011-14

Example of
clear responses
by peak chl a
across low
range of DIN



ECan dataset, 24 sites in hill & alpine catchments

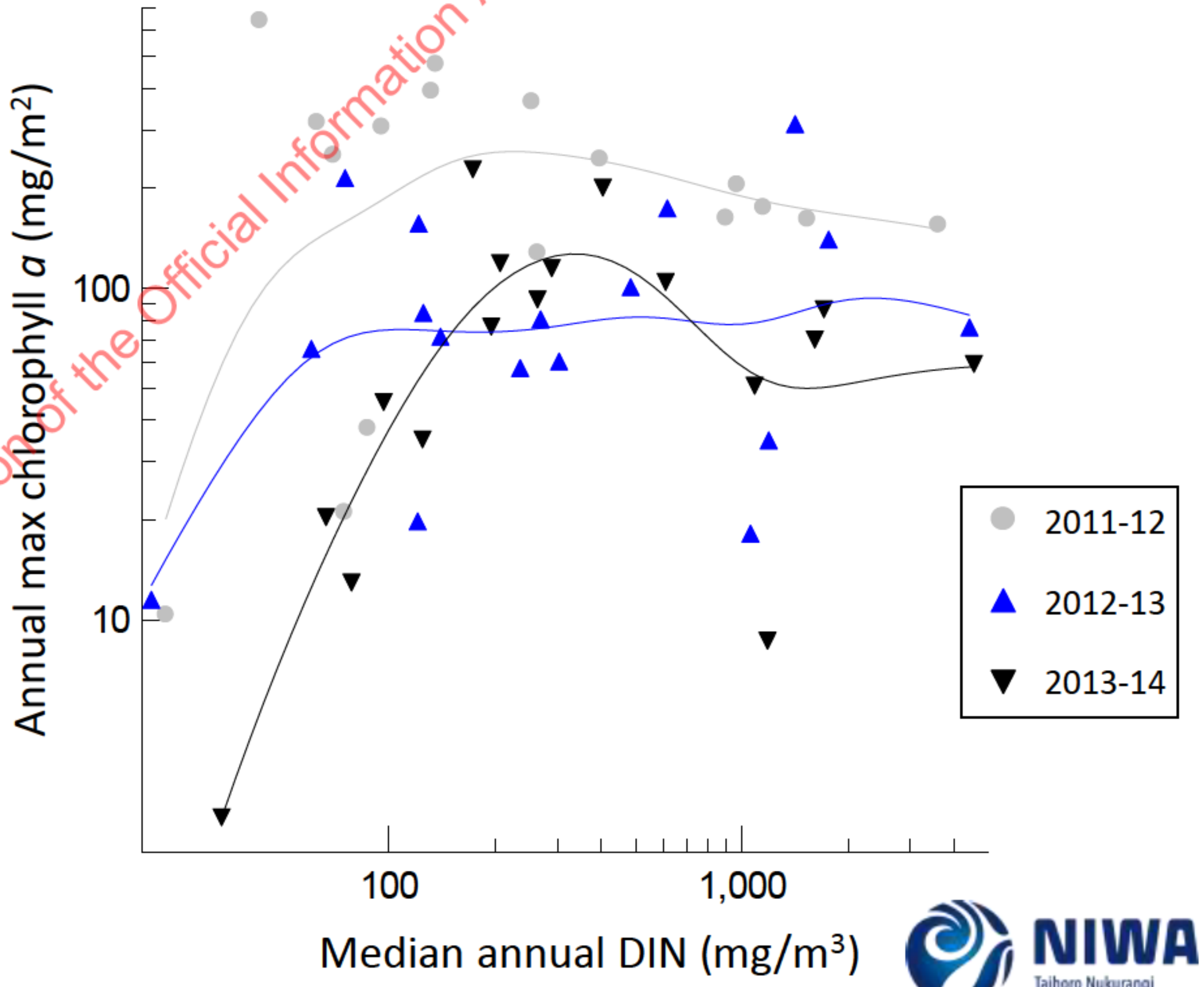
At unshaded hill sites – more complicated

- Predictors: DIN, conductivity, DaEF, substrate (% fine) [$R^2 > 0.7$]
  - ➢ +ve DIN vs. chl *a* correlation up to DIN 200 – 300 mg/m^3, then stabilises / declines
  - ➢ +ve effect of conductivity on chl *a* at low DIN (< 200 mg/m^3)
  - ➢ +ve effect of DaEF on chl *a*. (Accrual period based on 3 x median flow not a significant predictor.)

ECan dataset, 24 sites in hill & alpine catchments

At unshaded hill sites

- +ve DIN vs. chl *a* correlation up to DIN 200 – 300 mg/m^3, then stabilises / declines



Development of new models using new data

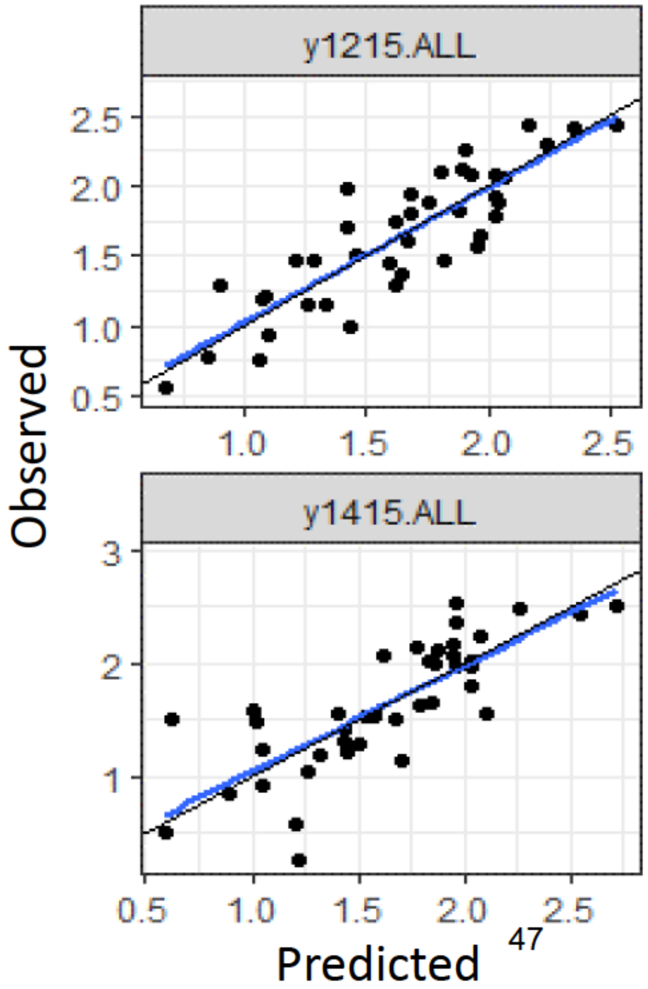
Example: Horizons 7-y dataset, 62 sites, 50 with flow data

Horizons 7-y dataset, 62 sites, 50 with flow data

At flow-sensitive sites with an EF (*n* = 40)

- Predictors available: DIN, DRP, cond., other WQ, substrate, temperature, DaEF, other flow.
- Strongest cross-validated GLM models from multi-year datasets (obs. vs. pred. $R^2 > 0.7$)
- Most important predictors: conductivity, DIN, DaEF (substrate, DRP & temperature also included)

92nd percentile chl *a*



In summary:

- New regional monthly periphyton & environment data produced models as good as Biggs (2000) (in terms of R^2)
- Subdivision of datasets (i.e., classification) was required to show up best relationships
- In most cases DaEF was an important predictor (not Da3xmedian)
- Same main predictors across regions (conductivity, DIN, DaEF)
- DRP only occasionally included as a predictor.

National models: recent analyses for MfE

NIWA
Taihoro Nukurangi

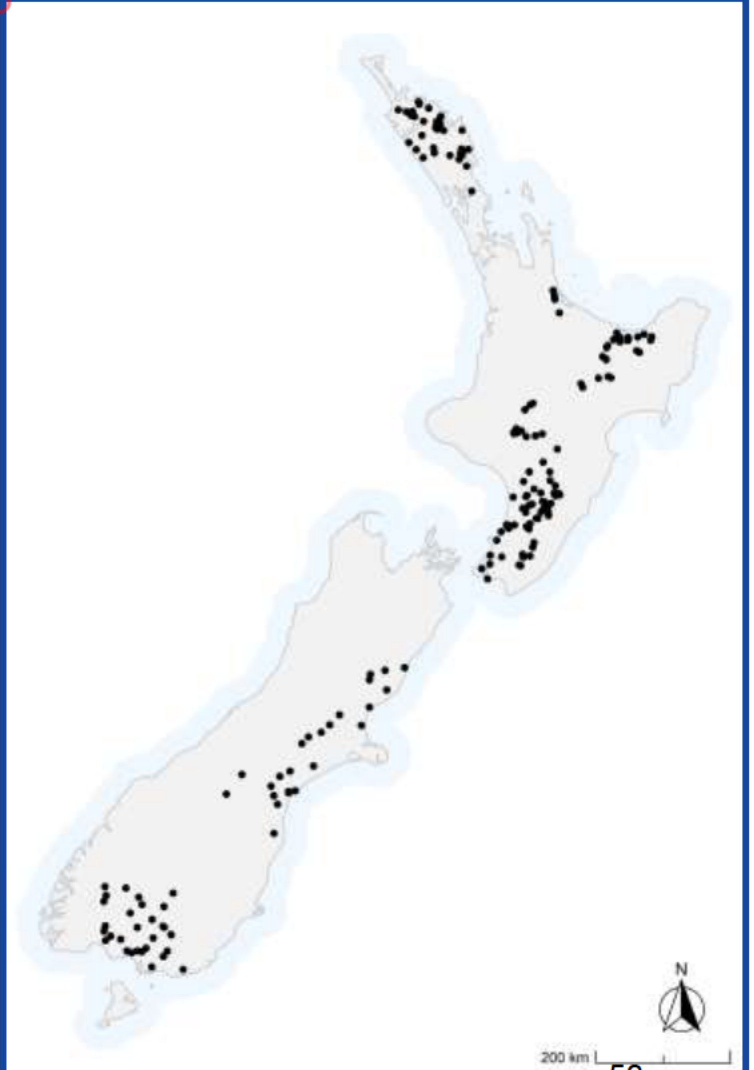
National models for periphyton

1. GLM analyses

   - Used all available <u>regional council data</u> (>190 sites, multi-year time-series)
   - Dependent variable: 92nd percentile chl a
   - Same methods as for ECan & Horizons analyses incl. estimating DaEF where possible
   - Compared national and regional results

2. Random forest models

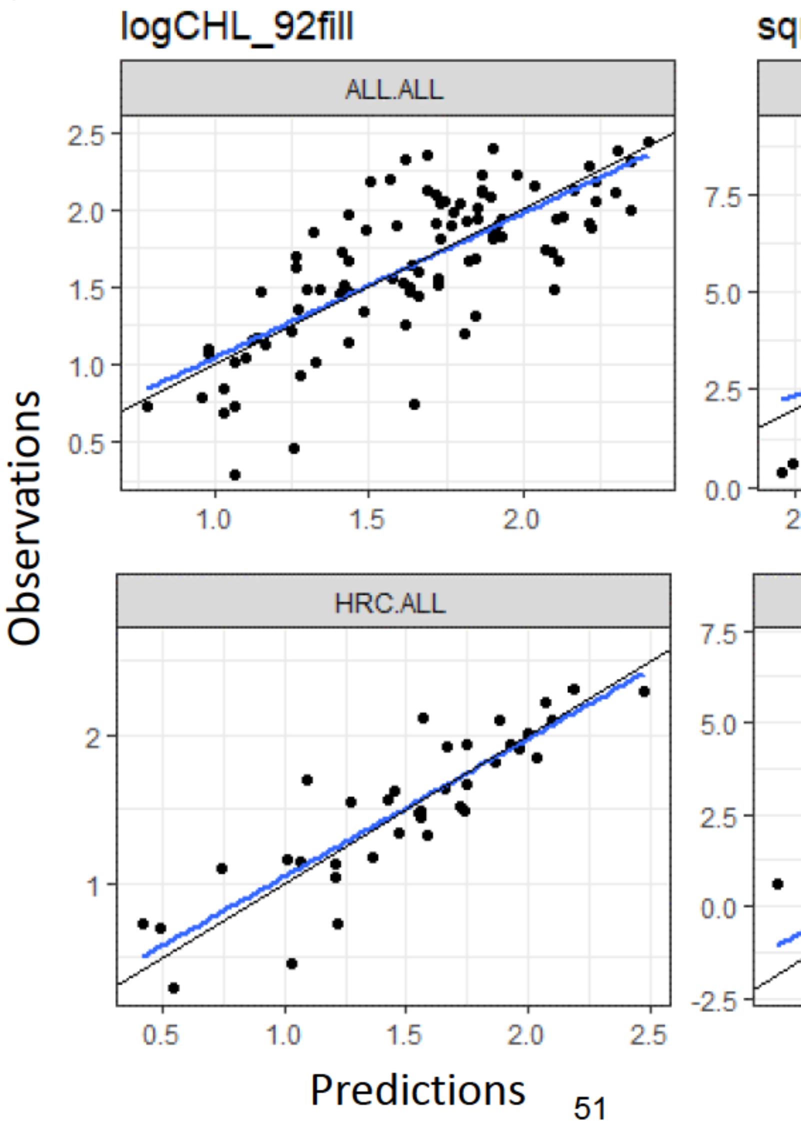
   - Predictors: modelled data linked to REC network



National models for periphyton

Summary of GLM results:

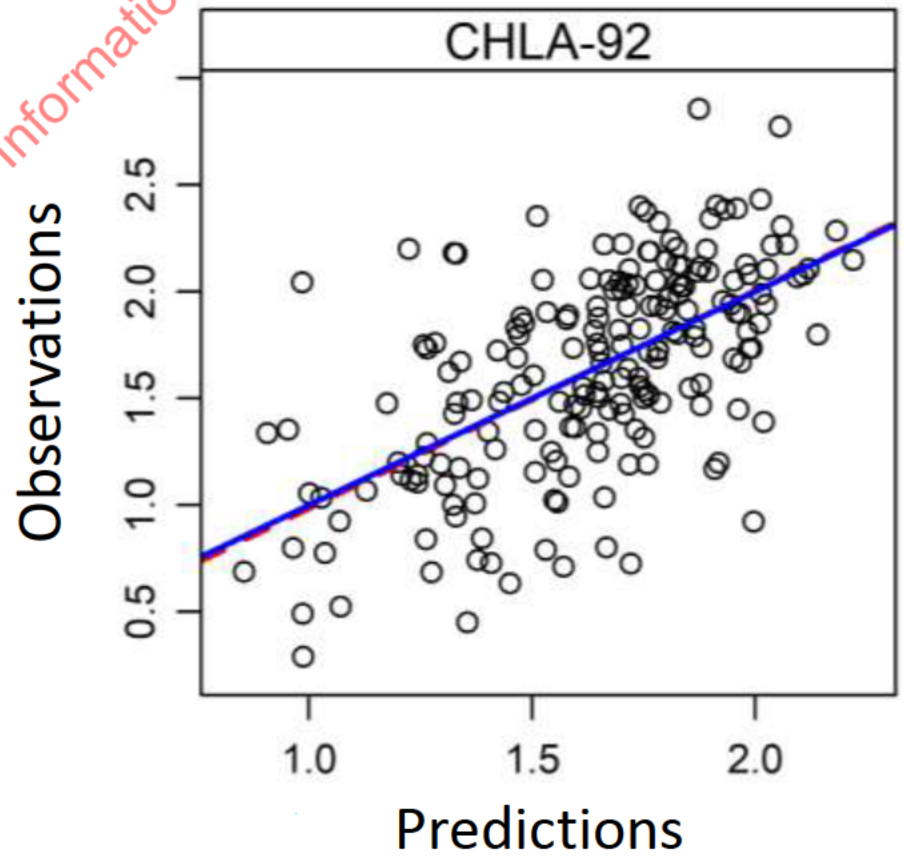
- All national models were weak (NSE ≤ 0.3)
- Regional models stronger than national models (NSE 0.5 – 0.9), except ECan (N.B. all sites included)
- Predictors, best national model: Cond., DIN, substrate, temp., flow vars (incl. DaEF), DRP
- DRP sometimes had negative coefficient. Problem for DRP limit-setting. May indicate inappropriate model type + other reasons (needs investigation).



National models for periphyton

Summary of RF results

- Performance better than GLM (NSE = 0.37, 0.41)
- Most important predictors: conductivity, NO_3-N (95^{th}pctile), TN, rain_var
- No phosphorus variable



Overall summary / conclusions

- If periphyton biomass (chl *a*) is to be used as the basis for defining nutrient attributes, note that:
  - Strong periphyton – nutrient relationships possible if multiple factors are taken into account;
  - Other factors may also be managed (e.g., shade, sediment, flow);
  - Data requirements are high (time-series) but RCs are collecting these data for NPS compliance (periphyton attribute);
  - Improved outcome when site classification applied;
  - DIN dominant nutrient predictor; DRP needs more investigation.

Next steps

Pathway to setting DIN / DRP thresholds

- Relationships already developed or under development covering at least some regions / sites, and site groups (classes) within regions

  - ➢ Set periphyton objectives (likely based on existing NPS-FM bands)

  - ➢ Apply classification to sites (e.g., REC-based & region specific)

  - ➢ Use appropriate models to identify DIN and DRP limits corresponding to periphyton objectives for each class

- This is essentially a site-specific approach which allows identification of potential effects of other factors as well as nutrients.

Thank you

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Document 35

Nitrate in drinking water

for MfE STAG

Chris Nokes

Standards and Guidelines

Science for Communities

Determinand	New Zealand MAV	Australian Guideline	WHO Guideline
Nitrate (mg NO_3/L) short-term	50	50 (bottle-fed, 3 < months) 100 (>3 months – adults)	50
Nitrite (mg NO_2/L) short-term	3	3	3
Nitrite (mg NO_2/L) long-term	0.2	-	-
NO_3/GV + NO_2/GV	1	1	1

In the 50 -100 mg/L range, water is considered safe for bottle-fed infants provided the water is of good microbiological quality. (WHO)

NZ MAVs are based on WHO guidelines

Nitrate in NZ drinking waters

ESR Science for Communities

P2 Identification Programme data, 2000

Concentration Band	Number of Zones				Total
	Population band				
	<100	- 500	- 5000	> 5000	
Nitrate detected (>0.1 mg/L)					529 (62% of assessed zones)
Nitrate concentration > 50% MAV	26	18	3	3	50
Nitrate concentration > 50% MAV	2	4			6

86% of these zones were sourced from groundwaters

2017-18 P2 determinands: NO_3 - 12 zones; $NO_3 + NO_2$ - 1 zone.

Basis of MAV

- Protection against methaemoglobinemia (blue baby syndrome)

Increased by reduced gastric acidity

$$NO_3^- \rightarrow NO_2^-$$

$$+ \; Hb \xrightarrow{\text{Oxidation}} metHb$$

Unable to transport oxygen

Carcinogenicity

- Plausible mechanism

$$NO_3^- \rightarrow NO_2^-$$

Stomach

$$NO_2^- + \text{Amines and Amides}$$

$$\downarrow$$

N- Nitroso compounds

Possible human carcinogens

Carcinogenicity

WHO commentary 2011

- Epidemiological studies only suggestive of a nitrate-cancer link
- Epidemiological studies have various shortcomings, or found no correlation
- Findings of epidemiological studies inconsistent
- Occupation exposure studies show no link with cancer

Carcinogenicity - continued

- 2018 Danish study (cohort study)
  - Large, long-term databases linked
  - Resulting strengths: study population size; duration of follow-up, and longitudinal exposure data at the individual level.
  - Weaknesses: unable to control for confounders (eg, smoking, diet, alcohol, sedentary lifestyle, obesity)
  - Conclusion: increased risk of colorectal cancer (CRC) with exposure to nitrate in drinking water. Statistically significant increased risk of CRC and rectal cancer at nitrate concentrations greater than ca. 3.9 mg NO_3/L

Carcinogenicity - continued

Science for Communities

- 2016 Spanish-Italian study (case control study)
  - Findings similar to the Danish study
  - Able to control for known confounders that lead to colorectal cancer
  - Much smaller number of cases (ca 1,800 cf 2,700,000)
  - Conclusion: Increased risk of colon cancer from ca 4.3 mg NO_3/L and colorectal and CRC from ca 8.6 mg NO_3/L.

Carcinogenicity - continued

- ESR comment to Ministry of Health
  - A meta-analysis of this and other studies designed to look at a possible nitrate cancer link required – by WHO task group?
  - Wait for the meta-analysis.

Other health concerns

- Congenital malformations – one study, could not be confirmed
- Cardiovascular effects – inconsistent findings
- Effects on the thyroid – epidemiological studies (1980s – 1990s)
  - o little effect if iodine intake satisfactory
  - o other studies find no link
  - o new studies suffer from methodological and data problems

Nitrate management in drinking water

- "*Protection of source water is of paramount importance*" – Second fundamental principle of drinking water safety (Havelock North Inquiry Stage 2 Report)
- Health Act 1956 s 69U

  Duty to take reasonable steps to contribute to the protection of source of drinking water
- NES for Sources of Human Drinking Water
  - Provides the tool to protect source waters

Nitrate management in drinking water

Options for reducing health risks associated with nitrate

- Best control is prevention (including prevention of faecal contamination)
- Dilution
- Disinfection – helps minimise the role of infection in causing methaemoglobinemia
- Ion-exchange (groundwaters)
  - Regeneration of the resin
  - Disposal of the spent regenerant
- Biological denitrification (surface waters)
  - Operational complexities
  - Microbiological contamination of the final water

Nitrate management in drinking water - continued

Science for Communities

Options for reducing health risks associated with nitrate - continued

- Membrane technologies
  - Electrodialysis
  - Ultrafiltration
  - Reverse osmosis

  Cost and disposal of the concentrate
- Zero-valent iron, magnesium, aluminium
  - pH adjustment for optimum removal
- Distillation

Other hazards arising from nutrients

- Cyanobacteria/cyanotoxins
  - Prevention of bloom development is the best risk management strategy
  - Physical removal of cells at the start of the treatment train
  - Oxidative destruction of the toxins
  - Adsorption by activated carbon

Document 36

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Compiled lots of readily available data

Source or Source nutrient dataset	1	1 PCL only	1	1	4	5	1	9,10	7	8				
Source ecological dataset	n/a	n/a	2	3	4	5	6	n/a	7	8				
Ecological metric	n/a	n/a	MCI/QMCI/ OE	MCI/QMCI/ EPT	MCI/QMCI	MCI	IBI	n/a	Chl a	Chl a	Weight. Mean	Std. Err.	Min.	Max.
Nitrate														
Weight of evidence	1	1	2	2	2	2	1	2	2	2				
A/B threshold	0.03	0.08	0.02	0.28	0.08	0.00	0.00	0.17	0.12	0.10	0.10	0.04	0.00	0.28
B/C threshold	0.06	0.12	0.29	0.84	0.43	0.60	0.60		0.43	0.63	0.46	0.28	0.06	0.84
C/D threshold	0.28	0.20	0.79	2.58	2.78	1.60	1.60	0.44	0.90	1.10	1.32	0.46	0.20	2.58
DRP														
A/B threshold	0.004	0.011	0.004	0.011	0.007		0.002	0.009	0.002		0.006	0.001	0.002	0.011
B/C threshold	0.008	0.014	0.014	0.021	0.031		0.007		0.007	0.110	0.019	0.003	0.007	0.031
C/D threshold	0.012	0.021	0.025	0.039	0.177		0.014	0.100	0.014	0.018	0.057	0.019	0.012	0.177

Value	Ecosystem health	
Freshwater Body Type	Rivers	
Attribute	Nitrate	
Attribute units	mg/l (milligrams per litre)	
Attribute State	Numeric Attribute State	Narrative Attribute State
	Annual median	
A	≤ 0.10	River ecosystem health high, similar to natural reference condition.
B	> 0.10 and ≤ 0.46	River ecosystem health good. Some degradation of life supporting capacity but ecosystem still functioning well.
C	> 0.46 and ≤ 1.32	River ecosystem health moderate to poor. Life supporting capacity degraded but acceptable.
National Bottom Line	1.32	
D	> 1.32	River ecosystem health bad. Severely polluted.

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Value	Ecosystem health	
Freshwater Body Type	Rivers	
Attribute	Dissolved Reactive Phosphorus	
Attribute units	mg/l (milligrams per litre)	
Attribute State	Numeric Attribute State	Narrative Attribute State
	Annual median	
A	≤ 0.006	River ecosystem health high, similar to natural reference condition.
B	> 0.006 and ≤ 0.019	River ecosystem health good. Some degradation of life supporting capacity but ecosystem still functioning well.
C	> 0.019 and ≤ 0.057	River ecosystem health moderate to poor. Life supporting capacity degraded but acceptable.
National Bottom Line	0.057	
D	> 0.057	River ecosystem health bad. Severely polluted.

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Value	Ecosystem health	
Freshwater Body Type	Rivers and groundwater	
Attribute	Nitrate-nitrogen (Ecosystem Health)	
Attribute Unit	Milligrams of nitrate-nitrogen	
Attribute State	Numeric Attribute State	Narrative Attribute State
	Nitrate-nitrogen (NO_3-N) – Annual median[1]	Description
A	≤ 0.10	Minimal nitrate-nitrogen enrichment
B	> 0.10 and ≤0.28	Mild nitrate-nitrogen enrichment
C	> 0.28 and ≤ 0.46	Moderate nitrate-nitrogen enrichment
D	> 0.46 and ≤ 0.89	Substantial nitrate-nitrogen enrichment
National Bottom Line	0.89	
E	> 0.89 and ≤ 1.32	Severe nitrate-nitrogen enrichment
F	>1.32	Highly severe nitrate-nitrogen enrichment

Value	Ecosystem health	
Freshwater Body Type	Rivers and groundwater	
Attribute	Phosphorus (Ecosystem Health)	
Attribute Unit	Milligrams of dissolved reactive phosphorus (DRP) per litre	
Attribute State	Numeric Attribute State	Narrative Attribute State
	Dissolved reactive phosphorus (DRP) - Annual median[1]	Description
A	≤ 0.006	Minimal DRP enrichment
B	> 0.006 and ≤0.013	Mild DRP enrichment
C	> 0.013 and ≤ 0.019	Moderate DRP enrichment
D	> 0.019 and ≤ 0.038	Substantial DRP enrichment
National Bottom Line	0.038	
E	> 0.038 and ≤ 0.057	Severe DRP enrichment
F	>0.057	Highly severe DRP enrichment

Boxplot of modelled nitrate in Public Conservation Land rivers

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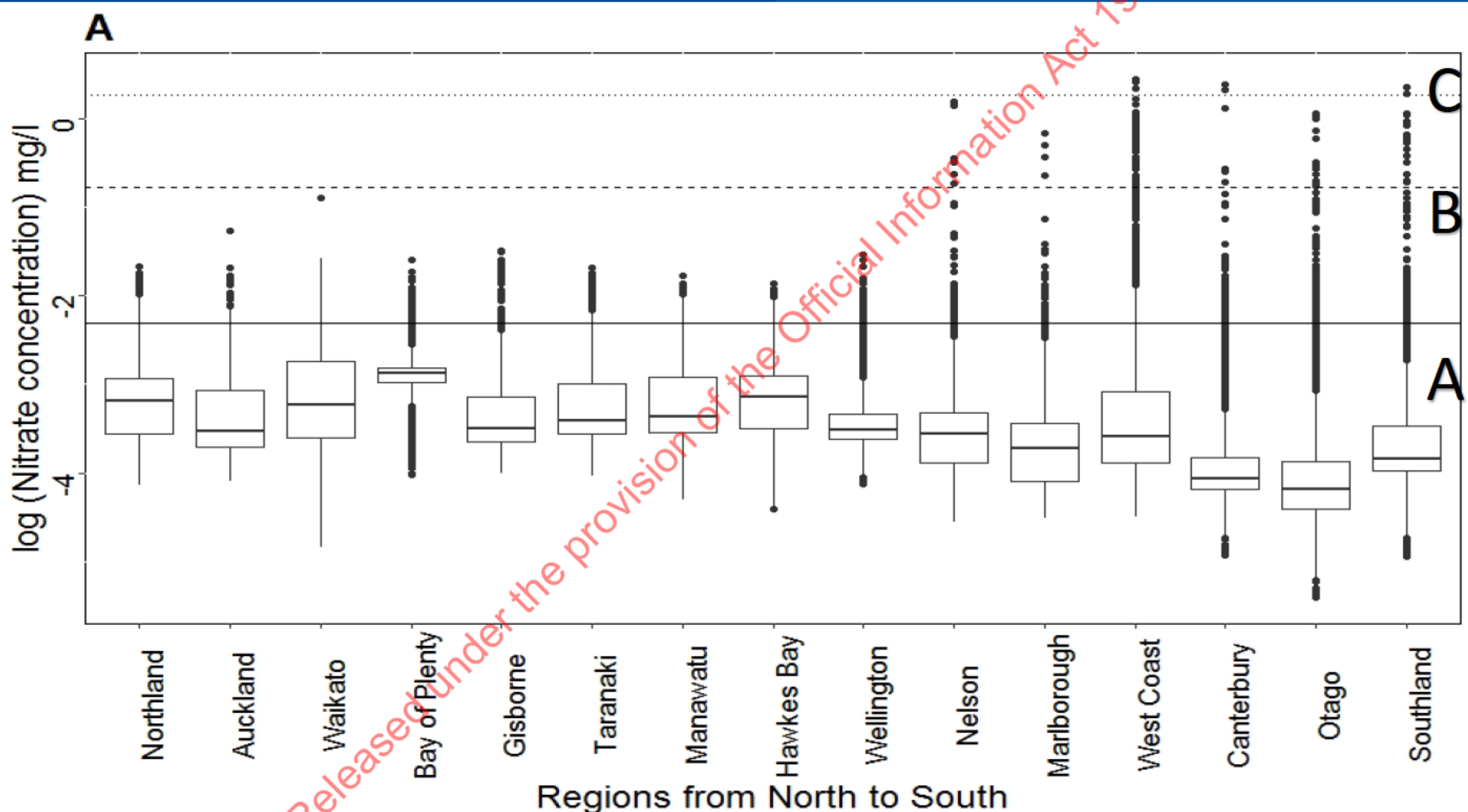

Boxplot of modelled DRP in Public Conservation Land rivers

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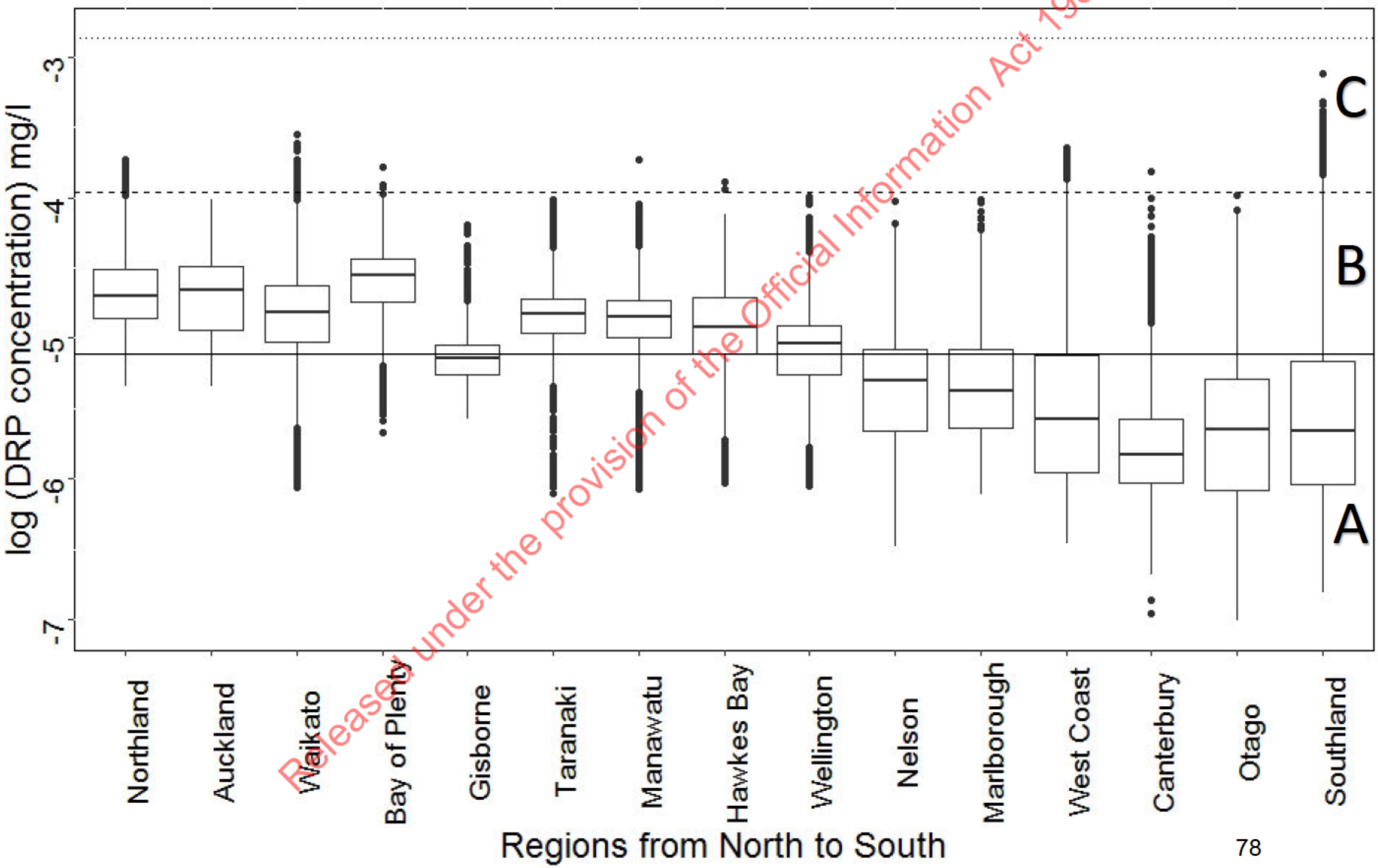


NPS state	NO_3-N (mg/l)	Percent	DRP (mg/l)	Percent
A	< 0.10	58.2	< 0.006	37.4
B	0.10 ≤ x < 0.46	25.2	0.006 ≤ x < 0.019	52.0
C	0.46 ≤ x < 1.32	14.1	0.019 ≤ x < 0.057	10.5
D	> 1.32	2.5	> 0.057	0.03

Other Countries

	USA[1]		South Eastern Australia[2]		Rest of Australia[2]		England and Wales[3]		
			Upland	Lowland	Upland	Lowland	DRP (mg/l)	Upland	Lowland
Total phosphorus (mg/l)	0.01-0.076*	Filterable reactive phosphorus (mg/l)	0.015	0.02	0.005-0.01	0.01-0.04	High	0.013-0.024	0.019-0.036
Total nitrogen (mg/l)	0.12-2.18	NOx (mg/l)	0.015	0.4	0.15-0.20	0.15-1.00	Good	0.028-0.048	0.040-0.069
							Moderate	0.087-0.132	0.114-0.173
							Poor	0.752-0.898	0.842- 80 1.003

Even China 2012

They use a five band system, I=A, II=B, III=C, IV=D, V=E

So nitrogen for them:

A=0.2 mg/l

B=0.5 mg/l

C=1 mg/l

D=1.5 mg/l

E=2 mg/l

Document 37

Nutrient concentration targets to achieve periphyton biomass objectives

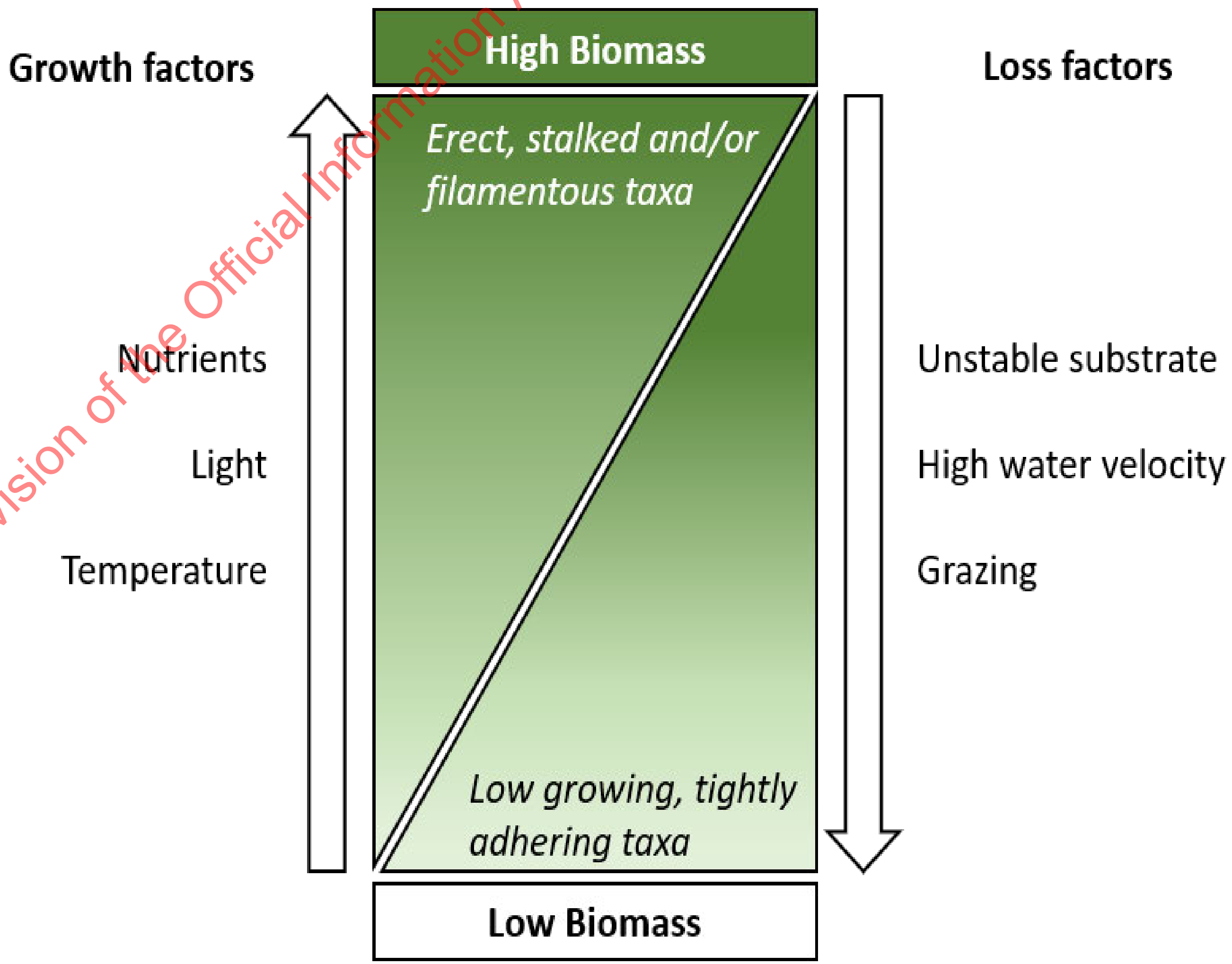
Ton Snelder

Smart models for aquifer management (SAM)

Snelder, T., 2018. Nutrient Concentration Targets to Achieve Periphyton Biomass Objectives Incorporating Uncertainties. GNS Science Report, Geological and Nuclear Sciences, Wellington, New Zealand.

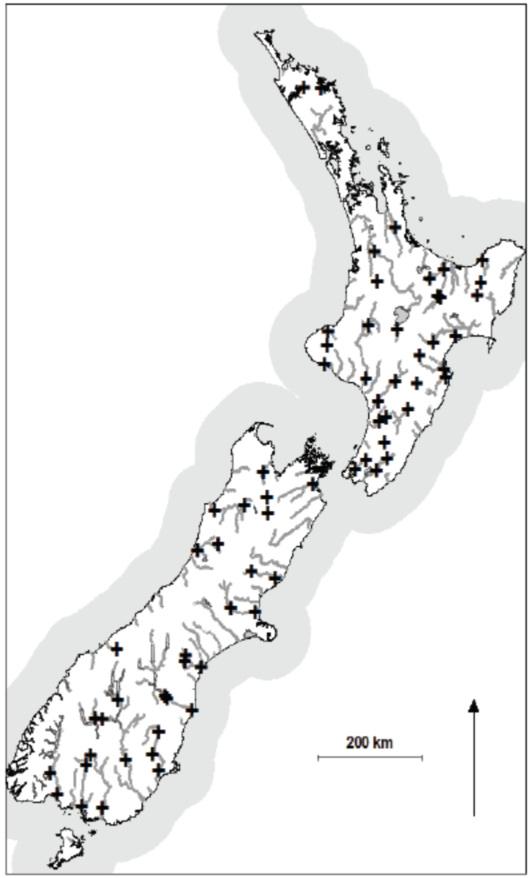
Basic assumptions

- We want to manage nutrients because of their effect on trophic state
- Trophic state is represented by peak periphyton biomass
- The effect of nutrients on biomass is complicated (mediated by) other factors

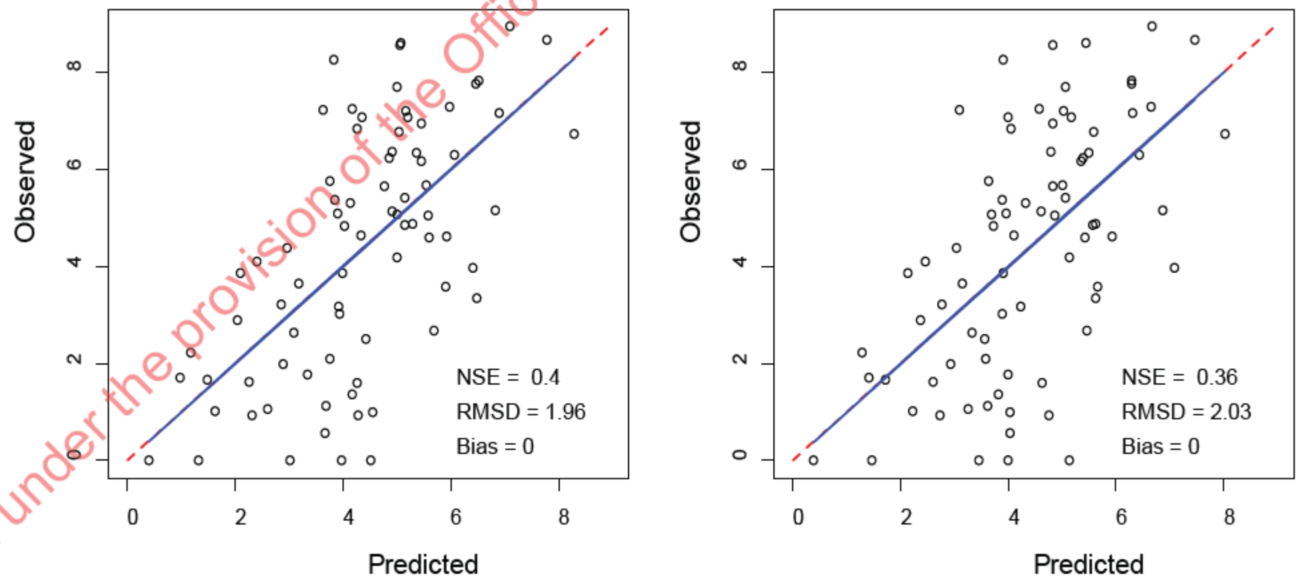


Models explaining periphyton biomass are generally weak

Training sites (NRWQN)



Model 1 includes TN and DIN:DRP and Model 2 includes DRP.



But consistent with conceptual understanding

$$\sqrt{WCC} = 0.93 - 0.16FRE3 - 5.8MALF7 - 0.02nNeg + 0.21T95 + 0.008PAR + 2.6log_{10}(TN) - 1.02log_{10}(NPratio)$$ **Model 1**

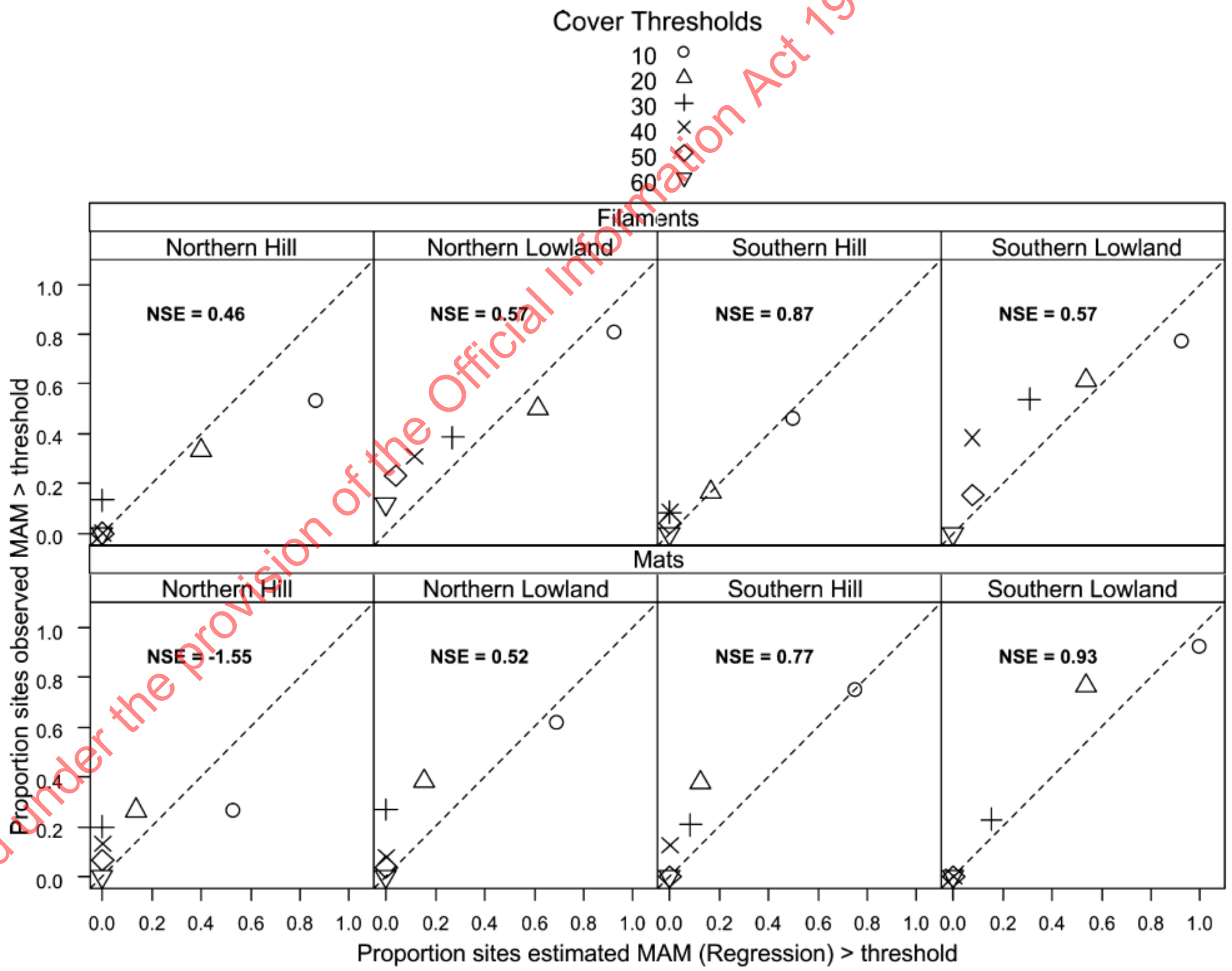
$$\sqrt{WCC} = 6.72 - 0.19FRE3 - 7.2MALF7 - 0.03nNeg + 0.25T95 + 0.007PAR + 21.3log_{10}(DRP)$$ **Model 2**

Biomass decreases with increasing FRE3, MALF7, nNeg ✓

Biomass increases with increasing T95, PAR, TN and DRP ✓

Weak models but reasonable broad scale predictions

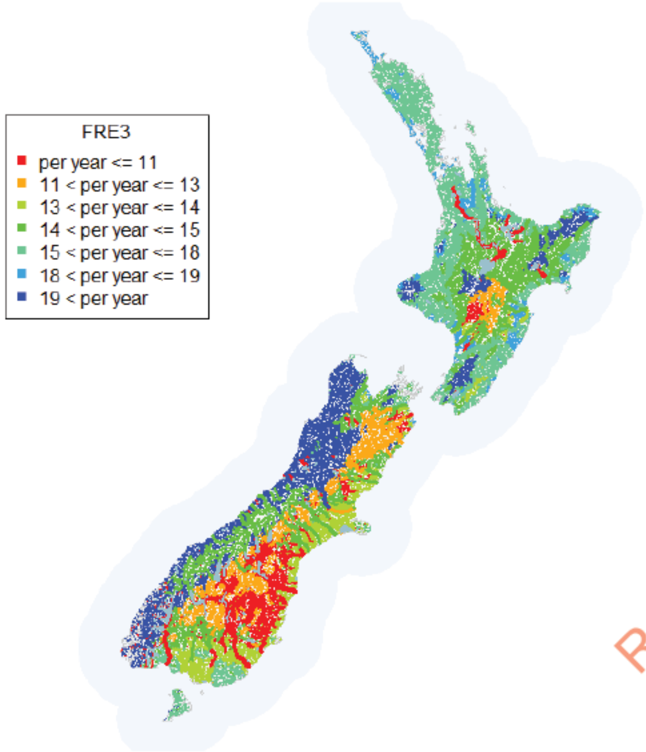
Used to predict the proportions of sites in a class that exceed a biomass threshold.

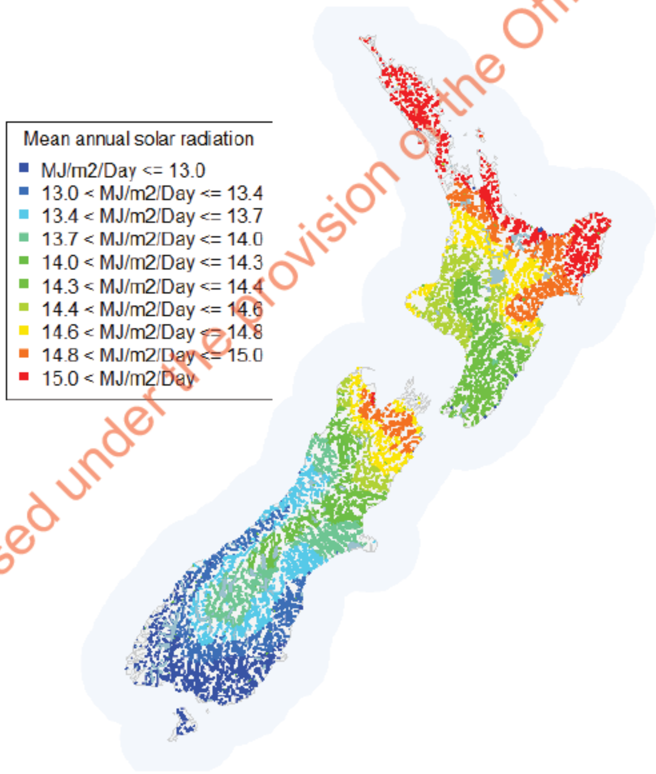


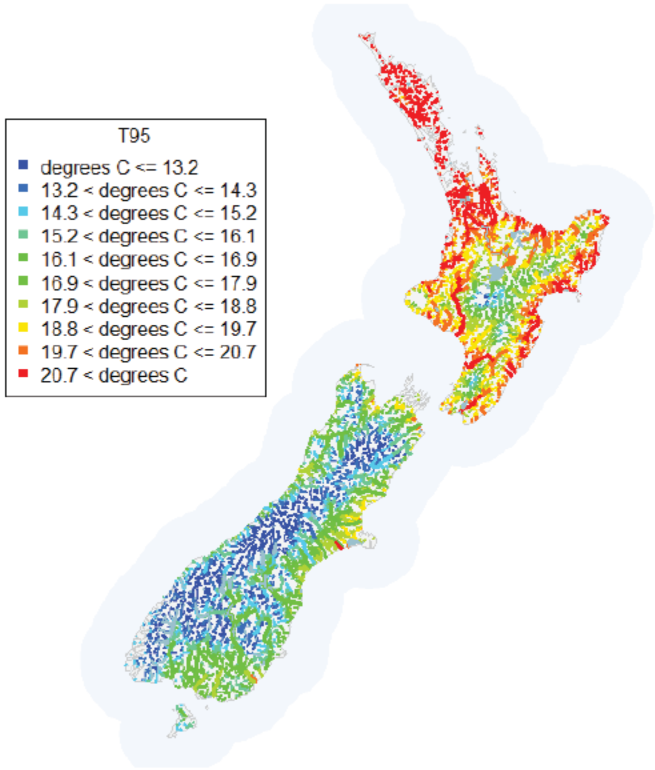
Snelder, T.H., D.J. Booker, J.M. Quinn, and C. Kilroy, (2014). Predicting Periphyton Cover Frequency Distributions across New Zealand's Rivers. Journal of the American Water Resources Association 50:111–127.

Nutrient targets by REC class – step 1

- Predict biomass for wide range of TN and DRP for whole network



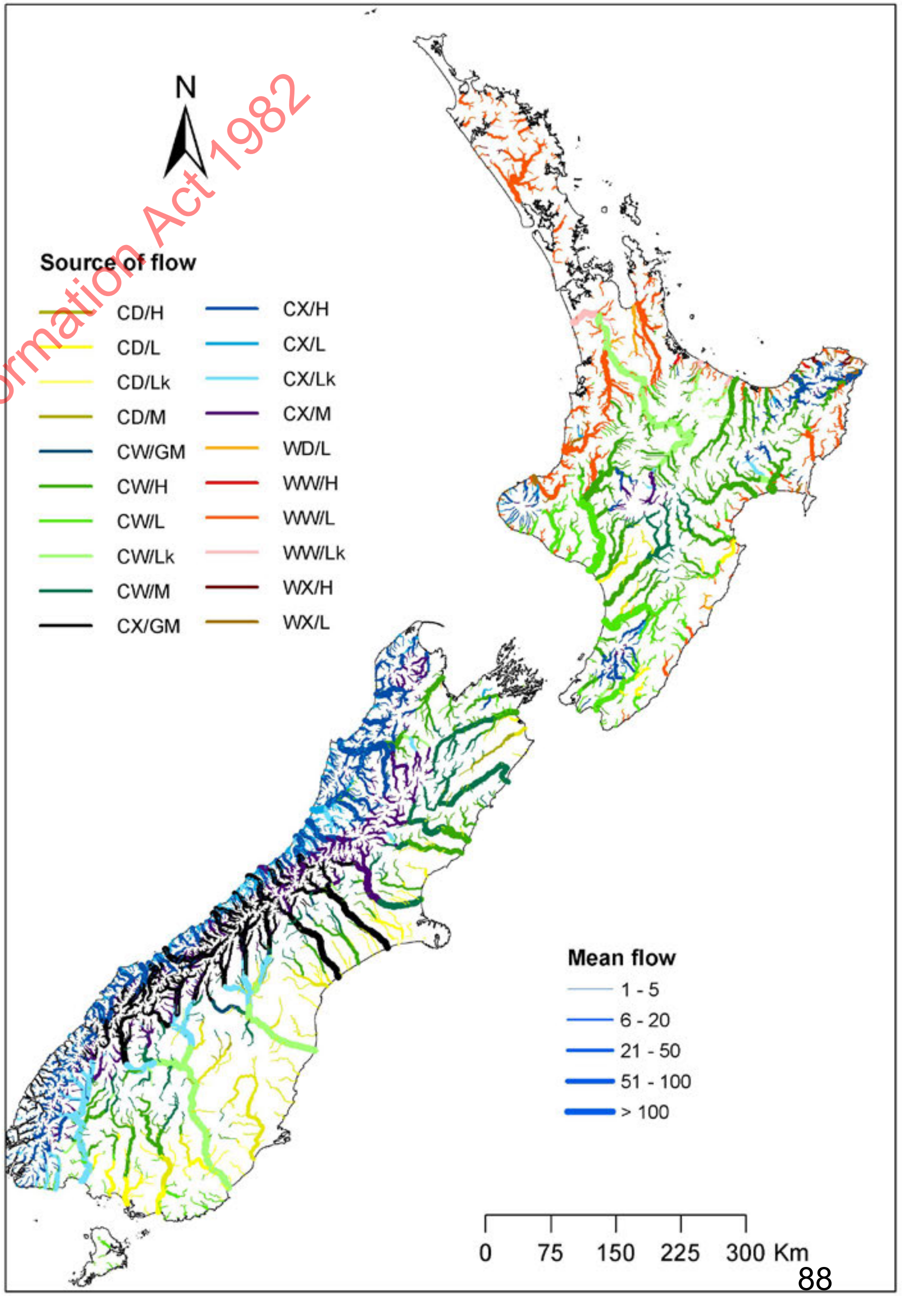




Nutrient targets by REC class – step 2

- For each REC Source-of-flow class:
  - Interrogate the predictions to determine TN and DRP concentrations at which 10%, 20% and 50% of segments* exceed biomass thresholds of:
    - 50 mg/m²
    - 120 mg/m²
    - 200 mg/m²

* these are termed the spatial exceedance criteria



Tabulated targets

TN targets (mg/m^3)

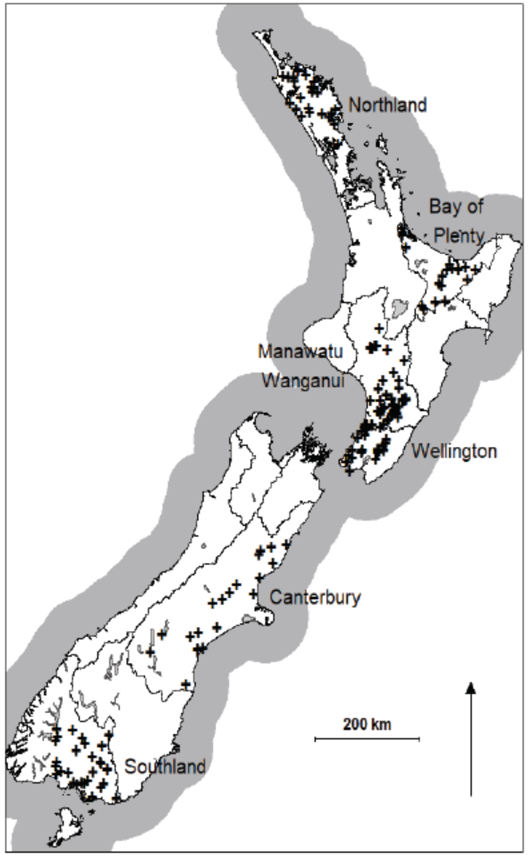
	Spatial Exceedance 10%			Spatial Exceedance 20%			Spatial Exceedance 50%		
	Periphyton objective (Chlorophyll)								
	T50	T120	T200	T50	T120	T200	T50	T120	T200
	Periphyton objective (NOF band)								
REC SoF	**A/B**	**B/C**	**C/D**	**A/B**	**B/C**	**C/D**	**A/B**	**B/C**	**C/D**
CX/GM	17	93	230	66	336	816	747	3425	7002
CX/M	28	162	395	117	582	1427	1375	5825	8632
CX/H	28	166	400	120	607	1440	1403	5909	8071
CX/L	21	124	302	85	433	1033	931	4184	7981
CX/Lk	7	40	97	27	134	321	261	1237	2889
CW/GM	9	48	117	31	155	367	279	1321	3118
CW/M	9	51	124	33	174	411	354	1640	3824
CW/H	10	53	129	37	189	451	408	1954	4368
CW/L	8	42	102	29	143	351	296	1384	3255
CW/Lk	5	28	68	18	92	221	175	819	1942
CD/M	6	31	75	20	99	240	184	864	2062
CD/H	5	27	67	17	89	213	164	767	1839
CD/L	5	28	67	18	90	224	176	833	1975
CD/Lk	5	24	59	16	80	191	149	697	1652
WX/L	8	46	114	32	160	386	338	1595	3719
WX/H	9	50	124	36	180	430	391	1826	4180
WW/H	13	72	177	52	260	636	604	2751	6058
WW/L	5	29	69	19	95	231	191	897	2140
WW/Lk	5	28	69	18	91	221	178	826	2015
WD/L	3	14	35	9	47	113	89	420	1009
WD/Lk	6	32	78	21	108	259	217	1005	2393

DRP targets (mg/m^3)

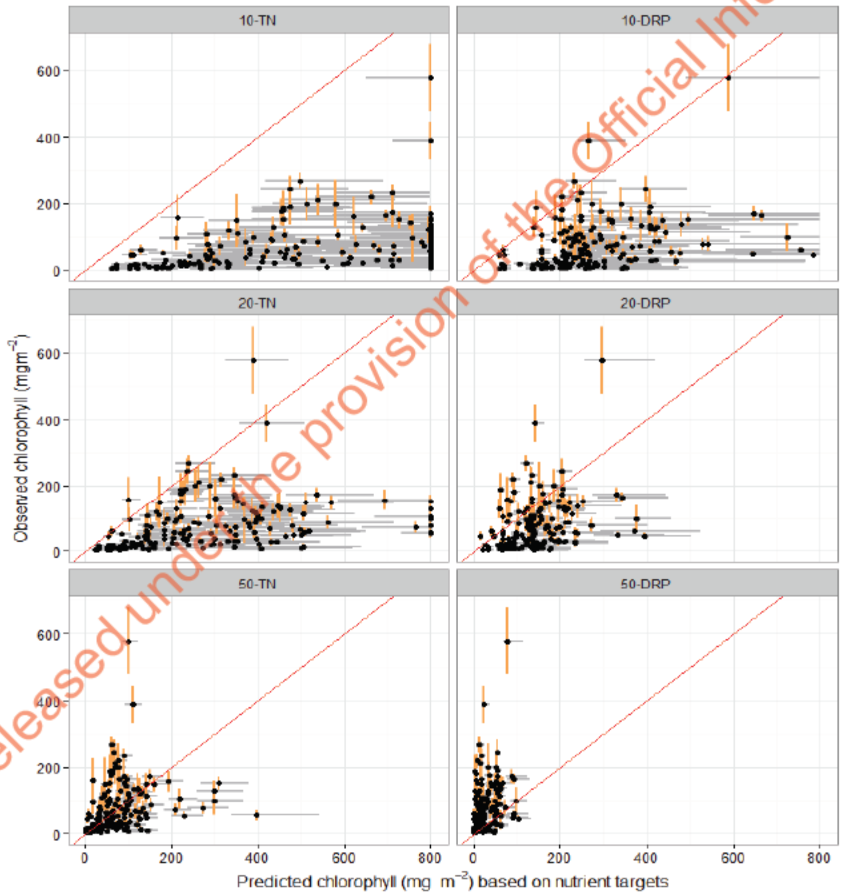
	Spatial Exceedance 10%			Spatial Exceedance 20%			Spatial Exceedance 50%		
	Periphyton objective (Chlorophyll)								
	T50	T120	T200	T50	T120	T200	T50	T120	T200
	Periphyton objective (NOF band)								
REC SoF	**A/B**	**B/C**	**C/D**	**A/B**	**B/C**	**C/D**	**A/B**	**B/C**	**C/D**
CX/GM	0.2	5.4	34.3	1.8	56.7	161.2	151	374	364
CX/M	0.4	18.6	76.1	8.2	114.1	289.3	292	403	369
CX/H	0.4	16.9	71.5	7.2	107.3	273.4	274	398	391
CX/L	0.2	7.4	42.3	2.4	67.3	186.8	168	380	381
CX/Lk	0.1	0.4	3.4	0.2	6.5	43.2	31	241	361
CW/GM	0.2	0.7	8	0.3	13.1	69	45	314	383
CW/M	0.2	0.8	7.9	0.3	14.5	69.1	54	339	382
CW/H	0.2	0.8	7.7	0.3	15.8	68.9	60	353	383
CW/L	0.1	0.3	2.6	0.2	5.2	37.6	30	228	387
CW/Lk	0.2	0.2	1.1	0.2	2.2	21.7	15	149	366
CD/M	0.2	0.2	1.4	0.2	2.4	23.7	15	157	371
CD/H	0.2	0.2	0.7	0.2	1.2	12.7	9	110	307
CD/L	0.2	0.2	0.7	0.2	1.2	12.6	9	110	307
CD/Lk	0.2	0.2	0.6	0.2	1.1	11.8	8	105	296
WX/L	0.1	0.5	4.4	0.2	8.8	50.5	41	283	367
WX/H	0.2	0.7	6.8	0.3	13.4	63.7	55	338	381
WW/H	0.2	1.5	14	0.6	27.3	94.5	88	387	399
WW/L	0.1	0.2	0.8	0.2	1.6	15.6	12	128	339
WW/Lk	0.2	0.2	0.8	0.2	1.3	13.9	10	120	325
WD/L	0.1	0.1	0.2	0.1	0.2	1.5	2	36	118
WD/Lk	0.1	0.2	0.7	0.2	1.2	13.1	10	121	327

Independent testing

173 test sites (RC monitoring)



Predictions based on criteria
(criteria & observations include uncertainties)



Performance

Variable	Spatial exceedance	Mean proportion exceeding (%)	95% confidence intervals (%)
TN	10	2.3	0.3 - 4.3
	20	8.8	5.3 - 12.3
	50	42.2	35.0 – 48.5
DRP	10	7.8	4.3 - 11.3
	20	19.9	15.0 - 24.8
	50	58.7	51.8 - 65.6

TN criteria were too restrictive for the test sites

Conclusions

- Notwithstanding the encouraging independent test results;
  - NRWQN periphyton observations were not collected to define nutrient criteria
  - The exercise was data-mining and pushed the input data hard
  - The results are potentially useful in the absence of data
  - But the method would greatly benefit from better input data in the future
- Keep in mind what the targets represent:
  - Concentrations that restrict non-achievement of the periphyton biomass objective to the spatial exceedance criteria (10%, 20% and 50% of sites)