Instructions to accompany the data requirement check list for calculating critical loads for N and S for forest ecosystems

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1. Introduction

The data checklist (attached) is organized into six categories: the first four correspond with the data inputs required for the Steady State Mass Balance Method approach for calculating critical loads and exceedance (site data, atmospheric/climate data, vegetation data, soil data). The fifth and sixth categories (forest health and surface water) include data that are used in further analysis of the model output.

A summary parameter table is provided for each data category. The parameters are categorized as:

1. *Model Input*, these parameters are required for input directly into the Steady State Mass Balance model;
2. *Intermediate calculations*, these parameters are required for calculating model inputs;
3. *Background data*; and
4. *Additional analysis*, data used for analysis of the model outputs

The parameters are labeled mandatory (M) or optional (O) according to the requirements of the US critical loads protocol. Note that there are some differences between these designations of mandatory and optional and those used in the ICP protocol. For more information regarding ICP protocol, please see http://www.icp-forests.org/Manual.htm.

In this document, we have also provided information meant to aid researchers in assembling the required data and, where appropriate, we have included lists ranking data sources, from most to least preferred.

Because these critical load calculations are made for the steady state, the climate parameters ideally represent long-term means (e.g. 30 years). In all cases, data should be provided for as long a time period as possible (after 1950), even if there are breaks in time. This allows us better understanding of the long-term conditions at each site.

2. Site description parameters

Site Description Parameters	Model input	Intermediate calculations	Background	Additional analysis
Latitude and longitude (decimal degrees)		M		
Elevation (m)		M		
Size of site (m or ha)		M		
Map of site			O	
Principle investigators			O	
Land-use history			O	
Disturbance history				O
Political jurisdiction			O	
Publications associated with site			O	

2.1 Explanation of the site description parameters

2.1.1 Latitude and longitude (decimal degrees)

2.1.1.1 For a plot: Coordinates should be for the center point of the site

First choice: GPS'ed to 5 decimal places

Second choice: If GPS coordinates are unavailable, please identify how the coordinates were determined

2.1.1.2 For a watershed or large site

First choice: GPS'ed center point coordinates should be accompanied by a GIS polygon file of the site

Second choice: GPS'ed center point coordinates should be accompanied by corner coordinates and a paper map of the site

Third choice: If GPS coordinates are unavailable, please identify how the coordinates were determined

2.1.2 Elevation (meters)

If applicable, include the minimum and maximum elevation of the site (m)

2.1.3 Size of site

First choice: The area of the site (meters or hectares)

Second choice: Plot radius (meters or hectares)

2.1.3.1 Is the site at the watershed or plot level?

2.1.4. Map of site

First choice: GIS files

a. Of site, showing sample locations
b. Of site
c. Of broader site area, showing proximity to other sites, weather stations, etc.

Second choice: paper maps

a. Of site, showing sample locations
b. Of site
c. Of broader site area, showing proximity to other sites, weather stations, etc.

2.1.5 Principal investigator(s)

a. Please include the names and contact information of the PIs
b. Please include the names and contact information for all individuals who handle the data, by data type

2.1.6 Land-use history

What management practices are in place? If there have been changes in management practices, what management practices were in place? Please provide details regarding the rotation length, harvest frequency, controlled burning, etc.

2.1.7. Disturbance history
Please provide as many details as possible regarding each major disturbance event, including when the event occurred, the severity, the extent of effect within the site, and any additional information about the disturbance that may be available.
Also note any anomalous weather events that need to be taken into account (e.g. an ice storm) and the time period of expected influence on the data (or identify any suspect data).

2.1.8 Political jurisdiction

2.1.9 Publications
In addition to publications and reports, please provide web site addresses if available.

3. Atmospheric and Climate data

Atmospheric/Climate Data	Model input	Intermediate calculations	Background	Additional analysis
Total deposition (kg/ha-yr and eq/ha-yr)) (N, S, Ca, Mg, K, Na, Cl, pH, total alkalinity)				
Wet deposition	M			
Dry Deposition	M[1]			
Bulk deposition	O			
Throughfall (additional parameters: conductivity and total N)	M[2]			
Precipitation volume (long-term; m)	M			
Mean annual temperature (long term, deg C)		M		
Mean annual evapotranspiration (m)	M			
Runoff (m/yr)	M			
Other				O

[1]May be modeled
[2]Throughfall deposition is assumed to be a measurement of total deposition

3.1 Explanation of the the deposition and climate parameters

3.1.1 Total deposition (kg/ha-yr)
Total deposition is required, which can be estimated in various ways (i.e., wet + dry, throughfall, modeled)

3.1.1.1 General information

i. Data should be reported as annual means, for as many individual years as available
ii. NH4 and NO3 data should be reported as NH4-N and NO3-N
iii. SO4 data should be reported as SO4-S?

3.1.1.2 Preferred sources of data

First choice: air quality station on site
Second choice: air quality station determined to be representative of the site
Third choice: modeled deposition

3.1.1.3 Sample collection and analysis

i. If established sampling protocol is used, identify protocol (NADP, CASTNET, AIRMoN, …)
ii. If site has unique sampling protocol, answer the following:
    1) How are samples collected, how many samples are collected, and at what frequency?
    2) How are the samples analyzed?
    3) How are the data dealt with if below the analytical detection limit?
    4) What QA/QC are in place?
    5) Where on the site (relative to other measurements) is the deposition measured?

3.1.1.4 Modeled data

i. Identify model
ii. Identify model assumptions
iii. What type of deposition was modeled?
iv. What uncertainty is associated with the model used?
v. What is the year or range of years represented by model output

3.1.1.5 Additional data (including, but not limited to)

i. Deposition data for any other elements
ii. Cloud and or fog deposition
iii. Ozone concentration data

3.1.2. Precipitation volume (m)

3.1.2.1 Type of data

<u>First choice</u>: 30-year mean monthly and annual precipitation volume
<u>Second choice</u>: monthly and annual means for as many individual years as available

3.1.2.2 Data source preferences

<u>First choice</u>: air quality station on site
<u>Second choice</u>: air quality station determined to be representative of the site
<u>Third choice</u>: modeled precipitation volume

3.1.2.3 Sample collection and analysis

i. How are samples collected?
ii. How many samples are collected?
iii. At what frequency?
iv. Is there or has there been any evidence of evaporation?
v. What QA/QC are in place?

3.1.2.4 Modeled data

i. What model was used?
ii. What uncertainty is associated with the model used?

3.1.2.5 Additional data (including, but not limited to)

i. Percentage of precipitation as snow
ii. Snow-free period of year (fraction of year): defined as the period between the first appreciable snowfall to last appreciable snowfall

3.1.3 Air temperature (degrees C)

3.1.3.1 Type of data

First choice: 30-year mean monthly and annual precipitation volume

Second choice: monthly and annual means for as many individual years as available

3.1.3.2 Data source preferences

First choice: air quality station on site

Second choice: air quality station determined to be representative of the site

Third choice: modeled air temperature

3.1.3.3 Data collection and analysis

i. At what frequency is temperature measured?
ii. What is the entire date range for available data?
iii. What QA/QC are in place?

3.1.3.4 Modeled data

i. What model was used?
ii. What uncertainty is associated with the model used?

3.1.3.5 Additional data

i. Growing season (fraction of year): defined as the period between five consecutive days above 0°C and five consecutive days below 0°C. If there are more than one such period, report the longest period.

3.1.4 Runoff (m/yr)

3.1.4.1 Type of data

First choice: 30-year mean annual runoff

Second choice: Mean annual runoff for as many individual years as available

3.1.4.2 General information

i. How is runoff measured?
ii. Is this a gauged watershed?
iii. Where on the site (relative to other measurements) is the runoff measured?
iv. Is there any missing data? If so, how is this accounted for?
v. Any other comments regarding runoff data?

3.1.5 Mean annual actual evapotranspiration (m/yr)

3.1.5.1 Type of data

First choice: calculated from 30-year mean annual runoff

Second choice: Mean annual runoff for as many individual years as available

3.1.5.2 Data source preferences

First choice: Calculated as measured precipitation minus measured runoff

Second choice: modeled deposition

3.1.5.3 Modeled data

i. What model was used?
ii. What uncertainty is associated with the model used?

3.1.6 Additional climate data (including, but not limited to)

3.1.6.1 Mean annual solar radiation
3.1.6.2 Mean annual wind speed
3.1.6.3 Mean annual air humidity

4. Tree data

Tree data	Model input	Intermediate calculations	Background	Additional analysis
Stand composition		M		
DBH (cm)		M		
Number of stems by species		M		
Nutrient concentration (N, Ca, Mg, K, P, S) by biomass compartment by species		M[1]		
Annual biomass removal rate		M		
Biomass by species (kg/ha)		M[2]		
Average height by species (m)			O	
MAI by species (kg/ha/yr)		O		
Volume (m^3/ha)		O		
Nutrient removal by species				O
Nutrient ratios				O
Stand age (yrs)				O
Other				O

[1]Can be estimated from literature
[2]Can be calculated using allometric equations

4.1 Explanation of the tree data

4.1.1 General information

The primary data that we need from the tree data section are nutrients lost from the site due to harvest or fire. Additionally, depending on how dry deposition is estimated, forest type may be required. For sites where loss of nutrients is not already calculated, the following provides the basic information required to estimate these losses.

4.1.2 Nutrient removal by species (mg/kg)

i. Data required include Ca, K, Mg, N
ii. How is this measured or calculated?

4.1.2 Nutrient concentration by biomass compartment by species (mg/kg)

i. How are samples measured?
ii. Is heartwood included in the bole samples?
iii. How representative are the samples?
iv. Can you provide any quantitative assessment of the variability?

4.1.3 Total biomass (kg/ha) by species

i. Biomass by species: How is this calculated? What allometric equations are used?
ii. Biomass fractions by species (bark, bole, branch, foliage): How is this calculated? What allometric equations are used?
iii. Wet-to-dry biomass conversions, if available

4.1.3 Biomass removal rate by species (kg/ha-yr)

4.1.3.1 Removal rate by harvest

i. What type of harvest (e.g. whole tree, stem only, clear cut)?
ii. What is the cutting cycle?
iii. How was this biomass removal rate determined?

4.1.3.2 Removal rate by fire

We are only interested in biomass removal by fire if the fires occur regularly (at least once) within a rotation.

i. Are the fires controlled burns, wildfires, or both?
ii. What is the fire cycle?
iii. What was the intensity of the fire?
iv. Which biomass compartments were lost?
v. How was this biomass removal rate determined?

4.1.4 Additional information (including but not limited to)

i. Nutrient leaching from slash
ii. Wood density of dry biomass

5. Soil data

Soil Data	Model input	Intermediate calculations	Background	Additional analysis
Number of soil pits/site			M	
Soil depth		M		
Soil texture (by horizon)		M		
Soil bulk density (by horizon)		M		
Course fragments (by horizon)				
Parent material		M		
Soil series		M		
Mineralogy (by horizon)		O		
Soil profile descriptions			O	
Soil Map			O	
Organic matter percent or organic C (by horizon)		M		
Total N (by horizon)				
Extractable Al, Ca, Mg, K, Na (by horizon)		M		
Cation exchange capacity (by horizon)		M		
Base saturation (by horizon)		M		
Volumetric soil moisture (by horizon)		M		
pH ($CaCl_2$ and H_2O)				O
Other				O
Soil Lysimeter Data (by depth)	**Model input**	**Intermediate calculations**	**Background**	**Additional analysis**
pH				M
Alkalinity				M
DOC				M
Base cations (Ca, Mg, K, Na)				M
Al (total)				M
Al (labile)				M
NO_3-N				M
SO_4-S				M
NH_4-N				M
Cl				M
Other				O

5.1 Explanation of the soil data

5.1.1 General information

i. How many soil pits are on the site?
ii. What soil series are present on the site?
iii. What is the dominant series?
iv. What area percent does each soil series make up?
v. Is there a soil map for the site?
vi. Where on the site (relative to other measurements) are the soil pit(s) located?

5.1.2 For all chemical analysis

i. What method was used?
ii. How is the data dealt with if below the analytical detection limit?
iii. What QA/QC are in place?

5.1.3 Soil Lysimeter data

i. What type of lysimeter was used?
ii. How many samples are collected and at what depth and frequency?
iii. Are the samples filtered?
iv. How are the samples analyzed?
v. How is data dealt with if below the analytical detection limit?
vi. What QA/QC procedures are in place?

5.1.4 Soil moisture

5.1.4.1 Data sources:

First choice: measured data
Second choice: generalized data based on soil texture

5.1.4.2 Sample collection and analysis

i. How many samples are taken and at or across what depths?
ii. What is the frequency of sampling?
iii. What method is used?
iv. What calibration is used?
v. Any notes on landscape position
vi. Any notes on concerns or limitations of measurements (limited choice of algorithms, sampling inconsistencies, etc.)

5.1.5 Additional information (including but not limited to).
Please indicate methodology where appropriate.

i. Mean annual soil temperature
ii. Water holding capacity
iii. Flow rate through soil
iv. Leaching rates of H, Ca, K, Mg, Na, NO3, …
v. Proportion of CEC occupied by Al
vi. Al: BC ratio
vii. Denitrification
viii. Nitrogen fixation rates
ix. Soil N immobilization, biotic and/or abiotic
x. Rooting depth (is this measured or an approximation based on field observation?)
xi. Weathering rates

6. Forest health data

Forest Health Data	Model input	Intermediate calculations	Background	Additional analysis
Foliage transparency				O
Crown density				O
Dieback				O
Mortality				O
Insect damage and disease				O
Areas of forest decline				O
Vegetation structure				O
Other (lichens, …)				O

7. Surface water chemistry

Surface Water Data	Model input	Intermediate calculations	Background	Additional analysis
Size of catchment				O[1]
Alkalinity				O[1]
pH				O[1]
Conductivity				O[1]
Base cations (Ca, Mg, Na, K)				O[1]
NH_4-N				O[1]
NO_3-N				O[1]
SO_3-S				O[1]
Cl				O[1]
Al (reactive)				O[1]
DOC				O[1]
Other				O

[1]These data are the mandatory paramters for ICP Waters (http://www.iis.niva.no/ICP-waters/)

7.1 Explanation of the surface water data

7.1.1 General information

i. Provide volume-weighted mean and maximum annual concentrations
ii. Provide fluxes and details of how flux calculations were made
iii. If annual means are unavailable, please provide raw data
iv. Are measurements made at regular time interval or by event?
v. How are samples collected?
vi. How many samples are collected?
vii. How are the samples analyzed?
viii. How are the data dealt with if below the analytical detection limit?
ix. What QA/QC procedures are in place?
x. Please include any other measured variables

Data requirement checklist for calculating critical loads for N and S for forest ecosystems

Site Name: **Contact Person:** **Contact Information:**	**Mandatory or Optional**	**Check if available**		**Mandatory or Optional**	**Check if available**
1. Site Description Data			**2. Atmospheric/Climate Data**		
Latitude and longitude (center point)	M		Total deposition (N, S, Ca, Mg, K, Na)		
Elevation	M		Wet deposition	M	
Polygon file and/or plot radius	M		Dry Deposition	M	
Principle investigators	O		Bulk deposition	O	
Size of site	O		Throughfall	M	
Land-use history	O		Precipitation volume (long-term)	M	
Disturbance history	O		Mean annual temperature (long term)	M	
Political jurisdiction	O		Mean annual evapotranspiration	M	
Publications associated with site	O		Runoff	M	
			Other	O	
3. Tree Data			**4. Soil Data**		
Stand composition	M		Number of soil pits/site	M	
DBH	M		Soil depth	M	
Number of stems by species	M		Soil texture	M	
Nutrient concentration (N, Ca, Mg, K) by biomass fraction by species	M		Soil bulk density	M	
Annual biomass removal rate	M		Parent material	M	
Biomass by species	M		Soil series	M	
Average height by species	O		Mineralogy	O	
MAI	O		Soil profile descriptions	O	
Volume	O		Soil Map	O	
Nutrient uptake by species	O		Organic matter percent	M	
Nutrient ratios	O		Extractable nutrients (Ca, Mg, K, Na)	M	
Other	O		Cation exchange capacity	M	
			Base saturation	M	
			Volumetric soil moisture	M	
			Lysimeter data (see section 5 for parameter list)	M	
			pH	O	
			Other	O	
5. Forest Health Data			**6. Stream Water Data**		
Foliage transparency	O		Size of catchment	O	
Crown density	O		Alkalinity, pH, conductivity	O	
Mortality	O		Base cations (Ca, Mg, K, Na)	O	
Dieback	O		NH4-N, NO3-N	O	
Insect damage and disease	O		SO4-S	O	
Areas of forest decline	O		Cl	O	
Vegetation structure	O		DOC	O	
Other (lichens, …)	O		Al (reactive)	O	