Forest Service Air Program
Target Load Strategy
July 2014

Introduction

You have been directed to this Target Load Strategy because one or more critical loads have been exceeded on your forest. This Strategy will guide you through a process to develop target loads (TL) for incorporation into the forest plan, the final step in the critical loads (CL) assessment. Review all critical loads, deposition, and exceedance information developed under the CL Implementation Strategy before proceeding.

Critical loads are "quantitative estimates of exposure to one or more pollutants, below which significant harmful effects on specific sensitive elements (receptors) of the environment do not occur, according to present knowledge." Describing air pollution effects on ecosystems in terms of critical loads allows communication of this complex science to a broader audience. The effects of sulfur and nitrogen deposition most often considered are acidification of surface waters or forested ecosystems, or nutrient nitrogen enrichment impacting various receptors (e.g., diatoms, lichens, mycorrhizal fungi, herbaceous vegetation, and forests). Because receptors have varying sensitivities to air pollutant loads, multiple critical loads can be used to describe a continuum of impacts related to increasing deposition at a given location.

When deposition exceeds the CL, there is increased risk for negative ecosystem effects including changes in aquatic biota, decline in forest health, and changes in biodiversity. In Step 7 of the CL Strategy, areas where current deposition exceeds CLs were identified. CLs for these areas will now be used to develop target loads.

A target load (TL) is a level of deposition set by policy makers to meet their objectives; for natural resources managers, the objective might be to protect sensitive ecosystem components. The TL may be higher or lower than the CL based on the desired level of resource protection, economic considerations, "the life of the forest plan," and stakeholder input. Whereas the CL is a science-based threshold describing the amount of deposition an ecosystem can tolerate over the long term, the TL is a policy-based threshold that incorporates the concept of time (for example, the time required for a damaged ecosystem to recover if the total deposition does not exceed a specific load). Management should be engaged in the process of setting target loads, especially when determining the level of protection desired for key sensitive receptors and the timeline for achieving this protection.

This strategy outlines a process that can be used to develop target loads.

Proceed to Step 1 of the Target Load Strategy: Review Available CL Exceedances to Determine how to Set Target Load.

STEP 1: Review available critical load exceedances to determine how to set target load.

The process used to develop TLs will vary depending on the type of CLs exceeded, the magnitude of the exceedance, and the current condition of the sensitive resources. In most cases a TL can be developed by selecting the CL that protects the most sensitive receptor, and using this as the TL. In areas where critical loads are exceeded and resource impacts are apparent, managers may be interested in understanding if and when resource recovery can be expected, requiring additional analyses to model ecosystem processes before a TL can be established. In this step of the Strategy you will determine the appropriate TL selection process based on the type of CL exceeded, the magnitude of exceedance, and the current condition of the sensitive receptors.

There are three approaches to develop CLs used in this assessment: empirical, steady-state modeling, and dynamic modeling. Empirical CLs of nutrient nitrogen (for a variety of receptors) and steady-state CLs for acidity are hosted on the Portal. Some forests may also have access to CLs calculated for their area using dynamic models.

Most forests will have access to only empirical and steady-state modeled CLs. It is important to check with FS Air Specialists to ensure that CLs currently available adequately represent sensitive ecosystem components, prior to setting TLs. TLs can be developed easily by setting the TL equal to the CL in exceedance; in cases where multiple CLs are in exceedance, the TL should be set equal to the CL of the most sensitive ecosystem component. In some cases, a forest may want to develop a TL that is lower than the CL to offset some of the uncertainty surrounding CL and deposition estimates and ensure that sensitive resources are adequately protected from future damage. In other cases, for example in areas of severe CL exceedances, Line Officers may be interested in developing "interim TLs" that are attainable within the "life of the forest plan." Keep these considerations in mind when following the specific guidance outlined below.

Forests that have experienced negative ecosystem effects due to atmospheric deposition, such as surface water acidification, may have dynamic modeling results available and these can be used to develop a TL. Dynamic models require more site-specific data and are usually applied at the site or watershed level. These models can incorporate a variety of deposition scenarios, time frames, and ecological endpoints to provide an array of possible target deposition loads. Managers can then select a TL that represents the desired degree of ecosystem protection and time needed to achieve the selected level of protection. Dynamic modeling is discussed in Step 2.

Consider the critical loads in exceedance on your forest and identify the categories below that best fit your situation. Use the recommendations to develop a TL for each CL in exceedance. This suite of TLs will be considered by forest leadership in Step 3 of the Strategy.

Steady-State CLs
(e.g., CLs of acidity for surface water)

Empirical CLs
(e.g., CLs of nutrient nitrogen for lichens)

Steady-State CLs (e.g., CLs of acidity for surface water)

Critical loads were calculated using average water quality measurements from the most recent 5 years of data. If long-term water monitoring records are available for your forest, these values should be examined and considered before making TL recommendations. In addition, CL exceedance was only calculated at sites where surface water samples were collected; these locations may not be representative of the entire forest. To best assess the extent of aquatic acidification, surface water samples from sensitive areas are desired. You may want to postpone developing TLs until the calculated CLs of acidity for surface waters are more representative of your forest as a whole, or at least the areas expected to be most sensitive to acidification effects. See the Monitoring Strategy for recommendations on developing a surface water monitoring plan for these sensitive areas.

Category A: Current or projected deposition equals or exceeds the CL by a small amount and current resource measurements are very close to the desired critical threshold.

Current air regulatory programs may achieve enough deposition reductions to eliminate the CL exceedance sometime in the near future. In this case, it is more efficient and desirable to establish a target load based on these expected emissions reductions without incurring the additional expense of dynamic modeling, assuming dynamic modeling has not already been performed.

- *Recommend a TL that is at or slightly below the CL.*
- *Proceed to Step 3 to share these results with leadership.*

Category B: Current and projected deposition equals or exceeds CL by a large amount and resource impacts are apparent.

More information may be desired on time to recovery (or time to damage) in order to select a TL. This will require dynamic modeling results. Check to see if dynamic modeling has been conducted for your forest.

- *If dynamic modeling has already been conducted, proceed to Step 3 to share these results with leadership.*
- *If dynamic modeling has not been conducted, consider the availability of dynamic models for calculating target loads and the data collection needs and associated costs to determine whether the environmental impacts justify the expense of collecting/assembling necessary resource and deposition data and performing dynamic modeling. The forest should consult with research scientists and/or FS Air Specialists familiar with relevant ecosystems and critical loads to determine the appropriate path forward. Step 2 provides additional information on dynamic modeling.*
- *The forest may also consider setting the target load equal to the lowest CL (of all the ecosystem endpoints) until dynamic modeling results are available.*

Empirical CLs (e.g., CLs of nutrient nitrogen for lichens)

Category C: Current deposition equals or exceeds CLs.

Negative effects are presumably already occurring, given that this is an empirical CL. There are no models available to predict time to resource recovery.

- *Recommend a TL at or slightly below the CL.*
- *Proceed to Step 3.*

STEP 2: Conduct dynamic modeling to develop an array of target loads.

Work with research scientists, FS Air Specialists, or contractors familiar with your ecosystems (and critical loads) to determine the most appropriate dynamic model for your situation. Some of the dynamic models used for developing TLs (based on CLs of acidity) are:

- *Model of Acidification of Groundwater In Catchments (MAGIC) for surface water acidification and soils,*
- *Very simple dynamic model (VSD) for terrestrial ecosystems,*
- *PnET-BGC for both surface water and terrestrial ecosystems,*
- *DayCent for western terrestrial and aquatic ecosystems.*

Examine the data required by the model before deciding to proceed. Although the exact requirements will vary with the selected model, water chemistry, soil and/or soil solution chemistry, soil mineralogy, meteorological data, foliar chemistry, biomass information, and deposition scenarios will likely be required. Recognize that additional data may need to be collected in order to conduct the dynamic modeling exercise. FS Air Specialists should coordinate with air regulators to ensure appropriate deposition scenarios are used.

Agree on parameters for the dynamic modeling exercise including the time frames to consider, chemical/biological endpoints, and deposition scenarios. FS Air Specialists should work with the research scientist or contractor conducting the modeling to agree on the parameters for the dynamic modeling exercise, perhaps after consultation with line officers and other technical specialists.

- *Here is an example of what these decisions might look like for dynamic modeling of surface water acidification:*
  - *Time Frame: Provide hindcast for surface water chemistry (e.g., ANC) to 1860 (preindustrial pollution levels) and forecast to 15, 50, and 100 years into future.*
  - *Chemical/biological endpoints or thresholds: Use a critical water chemistry threshold (e.g., ANC= 50 ueq/L), and bracket this threshold by adding endpoints (e.g., ANC = 0, 20, and 100 ueq/liter).*
  - *Deposition scenarios: Project future deposition based on emissions and dispersion modeling including estimates from air regulatory State Implementation Plans, as well as estimates with reductions aggressive enough to ensure ecosystem recovery.*

Produce a target load table and graphs to show achievability of recovery by different dates (for an example see Sullivan et al. 2011). Ideally the dynamic modeling results and TLs would be published in peer-reviewed literature.

With dynamic modeling results in hand, proceed to Step 3.

STEP 3: Line officers select a target deposition load that results in acceptable resource protection.

Recommendations for setting TLs follow, however forests may have different approaches.

Review the CL and TL information using an interdisciplinary team approach, and formulate a recommendation for the line officers. The team might include a modeler, air specialist, biologist, physical scientist, silviculturist or forester, etc. (depending on the resources affected by pollution), and forest planner. Consider whether any line officers should participate in crafting the recommendation.

Educate the team on the critical load/target load concept and processes (critical loads and target loads, calculation methods, data sources, dynamic modeling methods, and results).

Use the following concepts in developing the recommendation:

- *Use a weight of evidence approach to develop a target load. A suite of TLs may be available for consideration, but generally TLs for each pollutant (S and N) are developed to protect the most sensitive receptors and are set equal to, or slightly less than, the CL.*
- *When dynamic modeling results are available, line officers will select a target load from the array provided based on resource concerns, time to recovery, etc.*
- *Some areas may be so damaged that a reasonable TL cannot be developed. These areas should be identified for restoration.*
- *If the forest contains a Class I area, and line offers have not selected the most conservative available TL, consider setting a more conservative TL for the Class I area (per the Clean Air Act requirements to protect AQRVs in Class I areas).*

Review the guidance set forth in the Management Strategy and present recommendations to forest leadership.

Line officers select a TL that represents the forest's air quality goals to provide a desired level of environmental recovery and/or protection.

Include the selected TLs in the plan revision and communicate these TLs to air regulators.