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Importance of Accurate Activity Data for National GHG Inventory Reporting

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Extended Abstract

The availability of activity data often constrains the ability of a compiler to conduct a high quality GHG inventory. Sources of existing data or collection of new data may originate from a census, survey, or expert judgement (Goodwin et al. 2006). A census is a full accounting of an activity through data collection from the entire population of interest, such as a questionnaire to all farmers, or a map of land use derived from remote sensing imagery. In theory, a census has no uncertainty because there is a complete representation of the activity in the data collected through a census. However, in practice, a census can have some uncertainty because of non-responses from a subset of the population. For example, some farmers may not return the questionnaire, or clouds may lead to gaps in data on a remote sensing image. An example of census that is used in a national greenhouse gas inventory is the U.S. National Land Cover Dataset (Homer et al. 2015, US-EPA 2018), which provides information on land use for estimating emissions and removals associated with terrestrial carbon pools (US-EPA 2018).

A survey differs from a census by limiting the collection of data to a sample of the population. For example, a questionnaire may be sent to a subset of the farmers, or remote sensing data may be collected from sample locations to classify land use. A survey requires a randomized sampling of the population in order to produce unbiased estimates of the activity. The results do have some uncertainty that can be quantified based on the survey design (Särndal et al. 1992). A key advantage of a survey compared to a census is that a survey requires fewer resources because data are only collected from a subset of the population. An example of a survey that is used in conducting a national GHG inventory is the U.S. National Resources Inventory (Nusser and Goebel 1992), which is used to estimate soil C stock changes in agricultural lands (Ogle et al. 2010, US-EPA 2018).

'Crowdsourcing' activity data is another option for data collection (Yu et al. 2017, See et al. 2015), and this approach is emerging as a way to reduce resource needs associated with data collection. 'Crowdsourcing' data can be done in way that follows the design of census with data collection from the entire population, or the design of a survey with data collection from a sample of the population. However, data collection may not meet the standards for either approach, which could lead to biases in results. Consequently, inventory compilers must

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evaluate the data collection approach in order to address potential biases in data that originates from 'crowdsourcing'.

Expert judgement is also option for collecting activity data (Goodwin et al. 2006). Experts can be interviewed or given a questionnaire in which they provide knowledge about practices or activities in a country. For example, Maia et al. (2010) used expert judgement on crop management to determine changes in mineral soil C stocks for the lower Amazon Basin of Brazil. While this is not a preferred method for activity data collection, it is better to use expert judgement to estimate GHG emissions for a GHG emission or removal source category, rather than have no information about the category. Furthermore, data can be collected through a census or survey in the future if the source category is identified as a key category. Note that key categories are sources of emissions or removals that dominate the level or trend in a national GHG inventory, and are typically given higher priority for improvements in a future inventory.

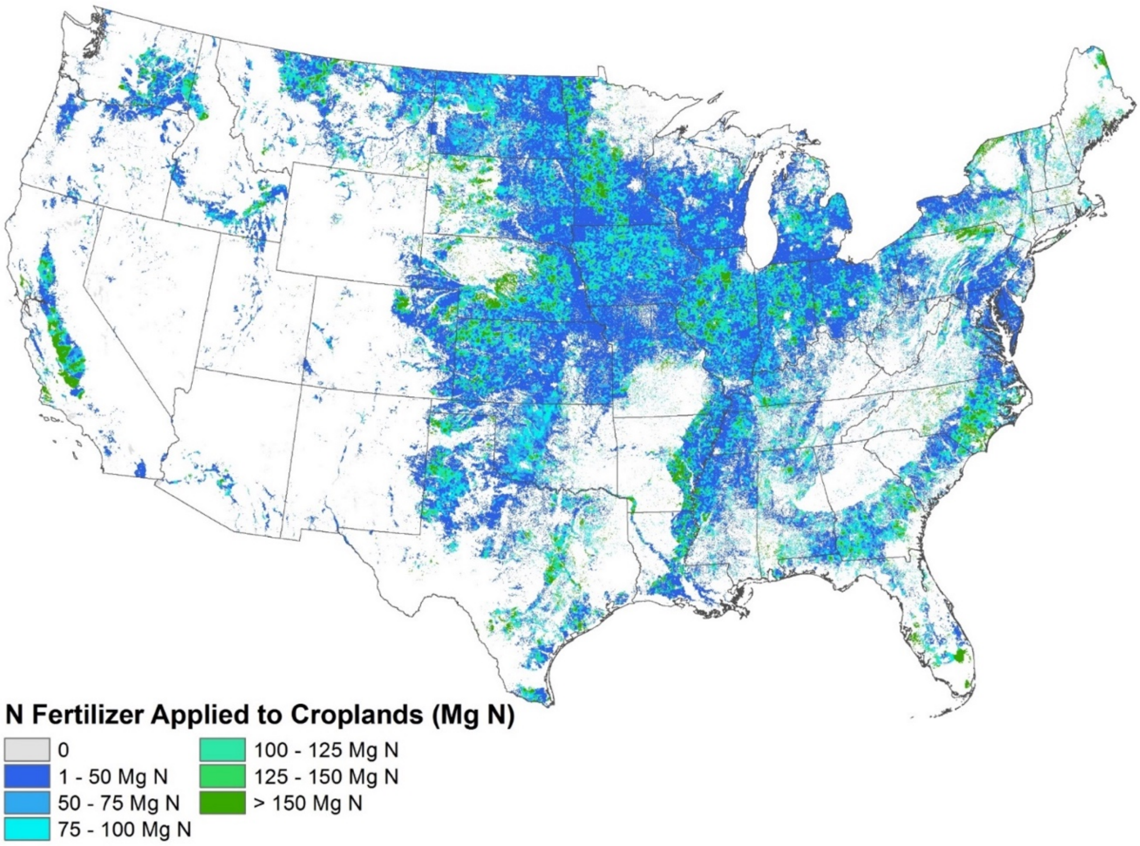

Figure 1. Mineral nitrogen fertilization rates for the conterminous United States in 2012.

All source categories of emissions or removals have a minimum set of activity data for the simplest methods, i.e., Tier 1 methods, which can be used to compile a national GHG inventory (IPCC 2006). For soil nitrous oxide (N_2O) emissions, these data requirements include the amount of mineral and organic N fertilization, amount of N returned to soils in crops residues, amount of soil C losses, and area of drained organic soils (de Klein et al. 2006). National datasets are often available that meet the basic data requirements. For example, data are collected in the United States on mineral fertilization rates by the US Department of Agriculture that meet the minimum requirements (Figure 1) (USDA-ERS 2015).

Activity data may also be available from international sources if there are not reliable national datasets. For example, the UN Food and Agriculture organization collects data on fertilization practices that can be used to estimate emissions of soil N_2O (UN-FAO 2019; Tubiello et al. 2015).
More advanced methods often incorporate other practices that influence emission rates, which, in turn, reduces uncertainty in the emission estimates. For soil N_2O, advanced methods may incorporate process-based models such as DayCent (Parton et al. 1998; Del Grosso et al. 2001) and DNDC (Li et al. 1992), which are able to simulate a broader suite of management impacts on soil N_2O emissions. These types of models can also address interactions between C and N cycling in which a practice has a direct impact on the C cycle, such as changes in CO_2 uptake through photosynthesis, but through the level of plant growth also has an impact on N cycling and N_2O emissions. An example of a Tier 3 method that is used in a national inventory is the DayCent ecosystem model. This model is used to estimate soil N_2O emissions from agricultural land in the United States (Figure 2) (US-EPA 2018).

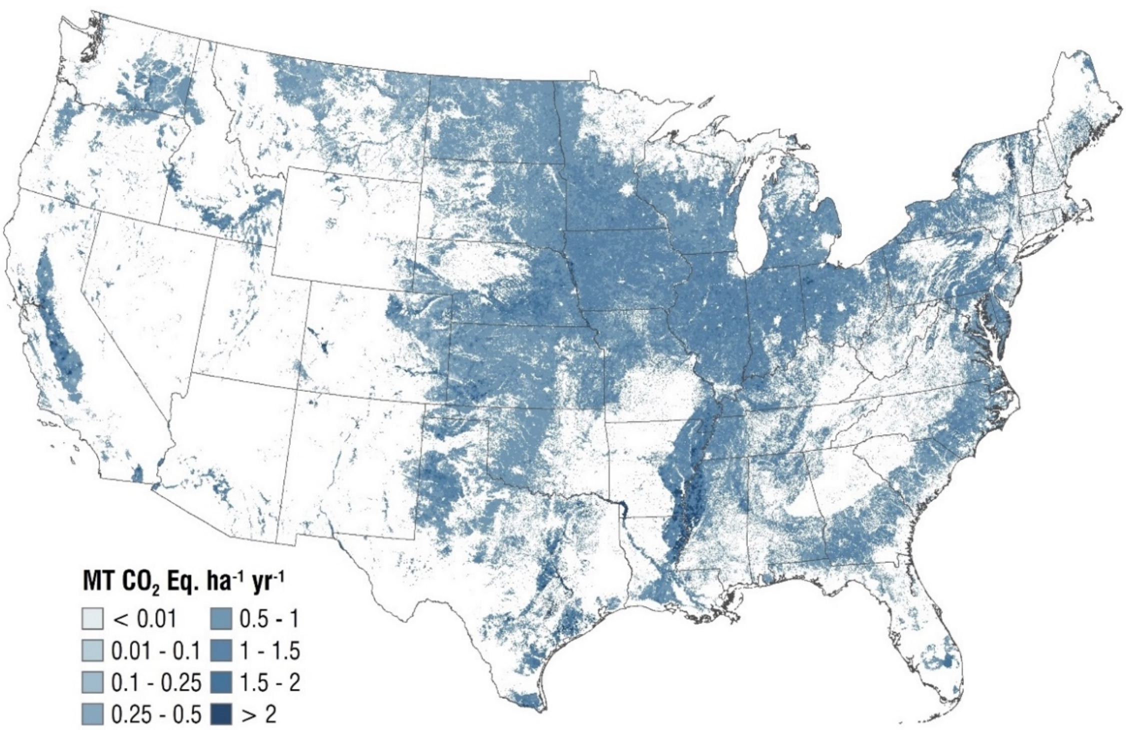

Figure 2. Soil N_2O emissions from croplands in the United States that has been estimated with the DayCent ecosystem model (US-EPA 2018).

Advanced methods may also be based on empirical models, such as non-linear response functions that capture higher rates of N_2O emissions with increasing amounts of N fertilization (Shcherbak et al. 2014; Scheer et al. 2016). For soil N_2O, other practices can also be represented with more advanced methods, such as the influence of no-till management (van Kessel et al. 2013), and the impact of enhanced efficiency fertilizers (Akiyama et al. 2010).

Another key issue with activity data are potential gaps in a time series. In the IPCC guidelines, it is recommended that inventory compilers fill these gaps with data splicing or imputation methods (Irving et al. 2006). It is important that gaps in the time series are filled with representative values so that the resulting inventory is as accurate as feasible. Imputation methods can be as simple as using values from the nearest neighbor to fill-in the missing data, or as complex as using methods such as hot deck imputations and artificial neural networks.

The main objective in conducting a greenhouse gas inventory is to produce results that are reliable and credible for developing policy and management plans. While emission factors are critical for a GHG inventory, and should not be overlooked in developing an inventory, limitations associated with activity data are a key dependency to compiling an inventory that is reliable and credible. Therefore, countries need to ensure unbiased data are collected on a regular basis through a census or survey, or expert judgement, in order to take appropriate actions associated with limiting anthropogenic impacts on the climate system.

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