Woodwell Climate Research Center

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August 16, 2022

**Re: Request for Information (RFI) on Federal Old-growth and Mature Forests**

To whom it concerns:

Thank you for this opportunity to comment on the definition of Federal old-growth and mature forests. We encourage the Forest Service and Bureau of Land Management to adopt definitions of mature and old-growth forests that are based on a simple, straightforward approach to maturity and that are based on ecological forest characteristics that can be described using existing observation and monitoring data such as that collected by the Forest Service Forest Inventory and Analysis (FIA) program and ongoing remote sensing observations by USGS and NASA. This approach could be rapidly assembled and would allow the agencies to comply with E.O. 14072, which calls on the Secretaries of Agriculture and the Interior by April 2023 to define, identify, and complete an inventory of old-growth and mature forests on Federal lands, accounting for regional and ecological variations, as appropriate, and making the inventory publicly available.

The Woodwell Climate Research Center ("Woodwell") is a scientific research organization that works with a worldwide network of partners to understand and combat climate change. We bring 37 years of experience with societal-scale policies and solutions for decision-makers to take action. Woodwell's Carbon Program works across continents to find comprehensive strategies to promote natural climate solutions for reducing carbon in the atmosphere.

<u>Existing definitions of Mature Forests and Old Growth</u>

Existing definitions of mature forest range along an ecological succession gradient, encompassing various stages of maturity greater than "young." Forest succession is a gradual process that occurs over decades to centuries before reaching a stage of maturity involving late seral characteristics commonly referred to as "old growth." Mature forests are sometimes narrowly defined to be synonymous with old growth (e.g., Martin et al. 2016), which typically requires multiple forest attributes to be assessed. For example, Spies and Franklin (1991) developed a definition of old growth for the Forest Service that includes attributes such as tree size, accumulation of large dead woody material, number of canopy layers, species composition, and ecosystem function. A similar definition was developed for old growth in an Eastern hardwood forest: "Stands with large, mature or over-mature trees (both healthy and decadent) comprising a plurality of stocking, usually having a multi-layered canopy in trees of various age classes. Stands include dead trees and relatively large amounts of decaying material on the forest floor." (Monongahela National Forest, 1986). One reason for the variety of definitions of mature and old growth is the need – most scientists agree – to reflect the diversity and complexity of these ecosystems (Pacific Northwest Research Station 2003).

The problem with complex and qualitative definitions of mature and old-growth forests, however, is that they are difficult to apply over large areas composed of multiple forest types. Recognizing that all such definitions will somewhat loosely represent these specific forest conditions, developing simpler definitions that can be consistently applied across a wide variety of ecosystems but still reflect ecologically relevant developmental markers can join practicality and function. A recent example of using FIA data to classify stand structural stages (pole, mature, and late) is based on the relative basal area of canopy stems in various size classes (Stanke et al. 2020). Another recent study developed a forest maturity model to classify young, intermediate, and mature stands based on three spatial data layers: forest cover, tree height, and aboveground living biomass (Mackey et al., 2022).

Proposed Definitions of Mature Forests and Old Growth

Ongoing research on carbon stocks and carbon increment of mature forests from Woodwell and collaborators is leading to a definition of mature forests that is based on ecophysiology and stand succession (Harris et al. 2021; Mackey et al. in review; Walker et al. 2022). The proposed definition is designed to inclusively represent the broadest possible range of stand ages, coupled with a preponderance of large trees, and can be consistently applied to different forest types and geographic regions. Under this approach, stands that have a high percentage of small trees and few large trees are not considered to be mature. These are typically mixed-age stands that have been affected by recent natural disturbance or partial harvesting.

The definition of mature reflects the growth and size of the trees that comprise the stand, and is similar to the widely used forestry concept "culmination of mean annual increment" (CMAI), which is based on the stand age at which the volume growth rate of timber is maximized. The approach starts with calculating net primary production (NPP) by age class instead of volume by age class. NPP represents increments of biomass accumulation per unit of land surface per year. Then "culmination of net primary production" (CNPP), which is the stand age associated with maximum NPP, can be identified. The stand age associated with CNPP is the lower age boundary for defining mature forest.

Ecologically, CNPP occurs approximately at the age when the growing space in the ecosystem is fully covered by leaf area – i.e., tree canopy closure reaches 100%. After this age, NPP either stays constant or declines gradually, depending on tree species composition and other environmental factors such as nutrient availability. Several examples are shown in Figure 1.

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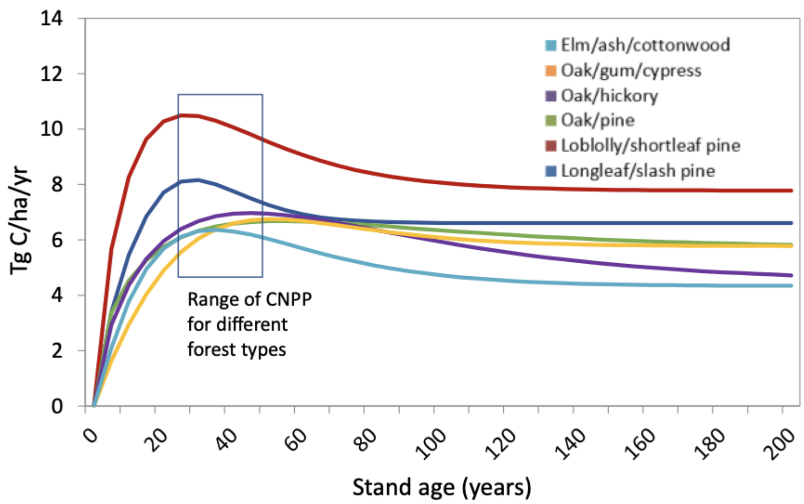


Figure 1. Net primary production (NPP) for selected forest types in the South (He et al. 2012). Culmination of NPP (CNPP) occurs at the stand age having the greatest annual increment rate, typically at or just after the tree canopy closes. Younger stands are those with ages less than CNPP. Older stands have ages greater than CNPP. CNPP is highly variable among forest types and geographic regions – in this example, from ages 23 to 45.

Some of the benefits of this definition of mature forest are that it 1) denotes the beginning of maturity; 2) it can be calculated for different regions and forest types using existing data sets; 3) it is a variable but consistently defined; and 4) it encompasses most if not all existing definitions of mature forest. Furthermore, NPP by stand age has already been calculated for different forest types in all U.S. national forests, so it is readily available for application nationwide (Birdsey et al. 2019; Dugan et al. 2017; He et al. 2012).

An extension of this approach could be developed to identify the subset of mature forest that is also classified as old growth. Following the Stanke et al. (2020) approach using FIA data, late successional forest (or old growth) could be calculated as the age at which more than two-thirds of the basal area exceeds a specified diameter threshold, which itself could be based on the average or median tree diameter associated with CNPP. An additional indicator variable that characterizes many definitions of old growth could be presence of significant quantities of down dead wood, though this is not measured at all FIA plots. However, standing dead trees are identified and measured at all sample plots and could be a useful proxy for current or future down dead wood.

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<u>Response to specific questions in the RFI</u>

*What criteria are needed for a universal definition framework that motivates mature and old-growth forest conservation and can be used for planning and adaptive management?*

- Can be consistently applied to different geographic areas, forest types, and management
- Uses existing, publicly available data
- Ecologically grounded
- Easy to understand and apply using available data

*What are the overarching old-growth and mature forest characteristics that belong in a definition framework?*

- Tree size and distribution of tree sizes at the stand scale (diameter and possibly height)
- Stand age or time since disturbance
- Relative stocking of live trees
- Standing and/or down dead wood

*How can a definition reflect changes based on disturbance and variation in forest type/composition, climate, site productivity and geographic region?*

- Relatively severe disturbances can be reflected in stand age or time since disturbance. Moderate or low severity disturbances, and disturbances that affect very small areas, may be considered as "background" or a normal part of mature or old growth forest ecosystem dynamics.
- An ecological-based definition that is variable but based on measurable forest characteristics can reflect variation in forest type/composition, climate, site productivity and geographic region.

*How can a definition be durable but also accommodate and reflect changes in climate and forest composition?*

- As stated above, an ecological but variable definition can be re-calculated over time to reflect changes in climate, composition, and other factors including disturbances.

*What, if any, forest characteristics should a definition exclude?*

- A practical definition must necessarily be a simplified representation of the full range of characteristics that are commonly associated with mature and old-growth forests. Not all characteristics need to be included in order to come up with a reasonable way to define these terms, and so those characteristics that are particularly difficult to measure or are not captured by existing observation and monitoring programs could be excluded. Examples might be assessing multi-layered canopies, down dead wood, or wildlife associated with stage of maturity.

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If you have any questions about our comment or would like to any additional information, please contact me at the email listed below.

Very truly yours,

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