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TO: Chief Randy Moore, U.S. Forest Service (USDA) and Director Tracy Stone-Manning, Bureau of Land Management (DOI)
FROM:The Wilderness Society
RE: Request for Comment on the Definition of Old-growth and Mature Forests

Comment summary: The Wilderness Society recommends using modeled total above- and belowground biomass accumulation curves to identify the age at onset of old-growth and mature forest conditions. Specifically, we recommend a universal definition framework for old-growth that is the age at which a forest stand is expected to achieve 95 percent of modeled maximum biomass and an age at onset of mature forest conditions equal to the culmination of mean annual increment of modeled total biomass. Curves can be fit for various forest types or forest type-groups and for stands of different site qualities to yield ages reflective of the different conditions under which forests grow, while employing a universal definition framework for the whole country.

Dear Chief Moore and Director Stone-Manning:

Conservation of late-successional (i.e., mature and old-growth) forests in the U.S. has been an issue of management concern since at least the 1970s, when discovery of their habitat value coincided with realization of their imminent disappearance. Following establishment of the Northwest Forest Plan, which protected most of the remaining late-successional forest in Washington, Oregon, and northwestern California, the issue went largely quiescent but has recently regained currency as awareness has grown of the value of mature and old-growth forests as carbon stores and their vulnerability to wildfire, climate change, and continued logging. On April 22, 2022, President Biden issued an executive order directing the Secretaries of Agriculture and the Interior "within one year, to define, identify, and complete an inventory of old-growth and mature forests on Federal lands" in anticipation of the development of policies "to institutionalize climate-smart management and conservation strategies that address threats to mature and old-growth forests on Federal lands" (EO 14072 Strengthening Our Nation's Forests, Communities, and Local Economies). The following constitutes The Wilderness Society's comments on the first component of that assignment, the definition of old-growth and mature forests. We have not organized these comments to align precisely with the questions posed in the request for comments. The majority of what follows pertains to the criteria needed for a universal definition framework, though other questions are touched on along the way.

In the E.O., President Biden wisely includes mature forests in the required inventory. This ensures that the inventory of older forest will not be limited to existing stocks of old-growth forest and that existing old-growth will not become the ceiling of future forest protection. Instead, the inventory will illuminate both the extremely depleted old-growth and the stocks of mature forest that can be drawn on to augment and replace that old-growth. As the Forest Service and BLM acknowledged in the Northwest Forest Plan, the "late successional" and "old-growth" forests that are the object of the Plan's protection "include the successional stages defined as mature and old-growth, both of which function as old-growth" (NWFP FSEIS 3&4-13). Thus, any inventory aiming to identify old-growth forests must include mature forests both for their current functional value as well as the role they will play in sustaining future old-growth. In the following discussion, we outline the various ways in which forests change with age and how those changes may inform a universal definition framework.

As forests age, they change in a number of important ways. First, and most obviously, trees get older, and this characteristic can be used to distinguish late-successional forests. This was the approach taken in the Northwest

Forest Plan where a mature forest is recognized as any stand over 80 years beyond the stand-initiating disturbance (FEMAT 1993). In setting this threshold, scientists relied on research that suggested that conditions associated with old-growth Douglas-fir forests of the Pacific Northwest begin to develop at 80 years and are well developed by age 200 (Spies and Franklin 1991). Similarly, the State of Minnesota uses 120 years as the age of onset of old-growth for several forest types, which is believed to correspond to the age at which sugar maple stands transition from a homogeneous overstory to a more complex structure (Frelich and Reich 2003). As these authors have shown, stand age alone can provide a straightforward - if sometimes hard to measure - means of defining old-growth and mature forests, though it misses much of the variability in forest conditions resulting from forest composition, site quality, and disturbance history (Wirth et al. 2009). In regions with widespread, dominant forest types that develop under a consistent climate and site quality, age alone can serve as a useful delimiter of the onset of mature and old-growth conditions, but it is unlikely to suffice across the range of conditions found throughout the U.S.

Alternatively, forest structure can be used to define old-growth and mature forests. As a forest recovers following major disturbance, it typically changes from an open stand of young saplings to a closed-canopied, relatively uniform forest, eventually transitioning into a dynamic system of horizontally and vertically diverse structure as trees die, fall over, and are replaced by younger trees (Bormann and Likens 1979, Oliver and Larson 1990). Forests subject to frequent, non-catastrophic disturbances (e.g., surface fire sustained through Indigenous burning) develop differently, but late successional forests of both types exhibit relatively large trees, decadence and decay, large snags, and spatial heterogeneity (Kaufmann et al. 2007). These structural characteristics can be used to define and identify late-successional forest, and in fact, structural definitions are by far the most common approach to identifying old-growth (Hilbert and Wiesczyk 2007). In response to a 1989 position statement on old-growth from the Chief of the Forest Service, regional definitions spelling out minimum densities of large live trees, large snags, and down wood, in addition to minimum ages of old-growth, were developed for most forest types in the U.S. (Capp et al. 1992, Gaines et al. 1997, Green et al. 1992, Mehl 1992, Tyrell et al. 1998, Various authors 1993). Stands that meet all the minimum criteria may be recognized as old-growth. Unfortunately, no similar definitions were developed to distinguish mature forests, making it impossible to use existing structural definitions to identify mature forest. Other authors have argued that no structural thresholds exist (Hunter and White 1997) and that stands are better described by a continuous index of "old-growthness" (Spies and Franklin 1988). In theory, index values pertaining to mature forest, as well as old-growth, could be identified, as has been done in the monitoring of the Northwest Forest Plan (Davis et al. 2015), but such values would be arbitrary without more research into the structural characteristics of mature forests.

A third way in which forests change over time is in their function, including important ecosystem services, such as soil stabilization, wildlife habitat, and, especially, carbon sequestration. When forests are young, their rates of photosynthesis and primary productivity can be very high, reaching maximum values as the forest canopy closes. Further stand development sees production drop from this peak, and with enough time, stands approach a maximum biomass, as respiration and decomposition balance photosynthesis (Odum 1969, Bormann and Likens 1979). This tendency for biomass to stabilize over time has been recognized from the earliest days of forest science (Assmann 1970, Davis and Johnson 1987) and has been suggested as a characteristic of old-growth forests (Wirth et al. 2009, Franklin et al. 2018). While some modest accumulation of carbon in the form of detrital buildup may occur after onset of the old-growth stage (Luyssaert et al. 2008), carbon accumulation can be modeled as reaching a maximum steady state (Janisch and Harmon 2002), and an age near that maximum, say the age at achievement of 95% of that maximum (to account for biomass accumulation in the old-growth phase), can be used to approximate a functional definition of old-growth.

An additional benefit of this approach is that the dynamics of carbon accumulation can be used to identify the age at onset of mature forest conditions as well as the age at onset of old-growth. Foresters have long used changes in forest productivity to mark significant points in forest development and have recognized the point at which periodic productivity of live tree volume drops below average productivity (the so-called "culmination of mean annual increment") as the point at which the stand reaches maturity and should be harvested to maximize yield over time. The same concept can be applied to the total biomass increment, including above- and belowground live and dead carbon, to identify the point at which a stand reaches maturity from a carbon accumulation standpoint. Using these objectively defined events in stand development, we can identify four phases of stand development: 1) "early seral" from stand initiation to peak periodic productivity; 2) "young forest" from peak productivity to culmination of mean annual increment; 3) "mature forest" from CMAI to the age at which 95% of maximum biomass is achieved; and 4) "old-growth."

This conceptual model can be useful for describing the four stages of forest development, but it is complicated by a number of factors. First, productivity, or the rate of accumulation of biomass, is affected by site quality. High quality sites can be expected to accumulate biomass more quickly than low quality sites and therefore reach peak productivity and maturity earlier (Assmann 1970). Logically, then, high quality sites can be expected to achieve higher levels of peak biomass than poor sites, which may or may not affect the timing of phase transitions. Larson et al. (2008) explored the relationship between site quality and forest structural development and concluded that high-quality sites do indeed reach old-growth structure more quickly. These differences mean that stands of the same forest type may reach mature and old-growth phases at different times depending on site quality. In addition, forest composition, initial conditions, and disturbance history can all have similar impacts, resulting in unique ages of onset of mature and old-growth conditions for each stand. Also, many forests, such as those affected by frequent or mixed-severity fire, do not follow the classic age progression assumed by this approach (Kaufmann et al 2007). Nevertheless, relationships between biomass and assessed "stand age" can be modeled using available forest inventory data to identify the age at onset of mature and old-growth conditions, and those ages can be combined with inventory plot data to estimate the extent of the mature and old-growth estate. Of course, use of age to identify mature and old-growth stands in the field suffers from the same disadvantages as those detailed by Wirth et al. (2009) for the age-based definitions described above, but stand age estimation is a standard method in field inventory and can be conducted fairly quickly without the need for elaborate plot-based methods.

The Wilderness Society has conducted a preliminary inventory using this functional definition of mature and old-growth forests and would be pleased to discuss it with the team implementing the Executive Order. Advantages of this approach are that it is a uniform methodology that can be applied across forest types or forest type-groups, without the need for unique, detailed structural descriptions; it can be applied readily (and quickly) to existing Forest Inventory and Analysis data; and it can be used to inventory mature forest as easily as old-growth. Disadvantages are that it involves a substitution of space for time, rather than being based on the longitudinal observation of individual stands, and therefore assumes stand behavior that may not match reality (Johnson and Miyanashi 2008, Derderian et al. 2016). As a result, it may misrepresent the trajectory of certain forest types, especially those that are strongly influenced by chronic, non-catastrophic disturbance (Keeton et al. 2018), but such an approach is consistent with methods (e.g., site quality curves, normal yield tables) that have been a standard part of forestry since its inception.

In addition to input on the criteria needed for a universal definition framework, the request for comments asked what characteristics should not be used to construct a definition. We recommend that the agencies not use measures of forest density, including canopy cover, basal area, or standing volume, as all of these measures may achieve high values early in stand development before important aspects of old forest structure develop. Also, many dry forest types operating under historical disturbance regimes may reach maturity without achieving high density, and other dry forests may have reached densities in the absence of fire that exceed those appropriate for the forest type. Forest density and biomass are important measures of forest condition, but threshold levels are a poor indicator of mature and old-growth conditions. In addition to discouraging the use of density, we also recommend against the application of a minimum patch size in definitions of mature and old-growth forests, and we oppose a requirement that forests have never been cut. Most of the East and much of the West has been subject to historical logging, and applying a "never cut" standard means that mature and old-growth conditions cannot be restored and the benefits of old forest structure for habitat and carbon sequestration would be denied to the majority of the continent. Nevertheless, uncut forests possess characteristics that are distinctly different from cut forests (Frelich and Reich 2003), and those differences should be noted in old forest conservation policy. Uncut forest should remain so, while restoration and management that sustains old-growth character should be encouraged.

In summary, in order to provide a universal definition framework that is capable of recognizing both mature and old-growth forests, we recommend the application of the "functional" definition described above. We recommend using the modeled relationship between biomass and stand age to identify the age at onset of old-growth and the age at culmination of mean annual increment of live and dead above- and below-ground biomass to define mature forest. We also recommend using the FIA database to identify plots that meet those age thresholds for forest types and different site qualities and to expand those plots to produce estimates of mature and old-growth area nationwide. In addition, we highly encourage the inventory team to map its results, whether those results are based on a functional or structural definition. We recognize that the effort to map inventory data out into space is a rapidly evolving area of research, and any map produced today is likely to become obsolete quickly, as methods improve. Nevertheless, the Forest Service has invested significantly in developing these methods, and the inventory resulting from the application of whatever definition is selected should reflect the state of the art.

Last, some have noted the distinction between an estimate, even one represented as an imputed map, and a true inventory, which includes verified field identification of sites. Gaines et al. (1997) distinguish between a "preliminary inventory," based on stand age as it exists in the Current Inventory of Stand Conditions, and a "field inventory" that includes field verification of the existence of old-growth conditions. We recognize that a true field inventory of old-growth and mature forest conditions is not possible in the time allowed by the Executive Order. Therefore, we recommend that where protocols already exist for preliminary inventory and protection, they should remain in place (e.g., Regions 6 and 8). Where such protection protocols do not exist, the ages of mature and old-growth forest derived from the method we describe here can be used to identify candidate stands for protection and future evaluation using structural criteria in the field.

Sincerely,
The Wilderness Society

References

Assmann, E. 1970. The principles of forest yield study: Studies in the organic production, structure, increment, and yield of forest stands. Pergamon Press, Oxford.

Bormann, F.H. and G. E. Likens. 1979. Pattern and Process in a Forested Ecosystem. Springer-Verlag, New York, Inc. 253 p.

Capp, J., B. Van Zee, P. Alaback, J. Boughton, M. Copenhagen, and J. Martin. 1992. Ecological definitions for old-growth forest types in Southeast Alaska. USDA Forest Service Alaska Region R10-TP-28.

Davis, L.D. and K.N. Johnson. 1987. Forest Management, 3rd edition. McGraw Hill, New York, NY.

Davis, R. J., J.L. Ohmann, R.E. Kennedy, W.B. Cohen, M.J. Gregory, Z. Yang, H.M. Roberts, A.N. Gray, and T.A. Spies. 2015. Northwest Forest Plan-the first 20 years (1994-2013): status and trends of late-successional and old-growth forests. Gen.Tech. Rep. PNW-GTR-911. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 112 p.

Derderian, D., H. Dang, H. G.H. Aplet and D. Binkley. 2016. Bark beetle effects on a seven-century chronosequence of Engelmann spruce and subalpine fir in Colorado, USA. Forest Ecology and Management 361:154-162.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Washington, DC: US Government Printing Office.

Franklin, J.F., K.N. Johnson, and D.L. Johnson. 2018. Ecological Forest Management. Waveland Press, Inc. Long Grove, IL.

Frelich, L.E. and P.B. Reich. 2003. Perspectives on development of definitions and values related to old-growth forests. Environmental Reviews 11(S1):S9-S22.

Gaines, G. [and others]. 1997. Guidance for conserving and restoring old-growth forest communities on national forests in the Southern Region. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region, Old-Growth Team. 121 p.

Green, P., J. Joy, D. Sirucek, W. Hann, A. Zack, and B. Naumann. 1992. Old-growth forest types of the Northern Region. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region. 58 p.

Hilbert, J., and A. Wiensczyk. 2007. Old-growth de?nitions and management: A literature review.BC Journal of Ecosystems and Management 8(1):15-31.

Hunter, M.L. Jr. and A.S. White. 1997. Ecological threshold and the definition of old-growth forest stands. Natural Areas Journal 17:292-296.

Janisch, J.E. and M.E. Harmon. 2002. Successional changes in live and dead wood carbon stores: implications for net ecosystem productivity. Tree Physiology 22:77-89.

Johnson, E.A., and K. Miyanishi, 2008. Testing the assumptions of chronosequences in succession. Ecol. Lett. 11, 419-431.

Kaufmann, M. R., D. Binkley, P. Z. Fulé, M. Johnson, S. L. Stephens, and T. W. Swetnam. 2007. Defining old growth for fire-adapted forests of the western United States. Ecology and Society 12(2):Art. 15.

Keeton, W.S., C.G. Lorimer, B.J. Palik, and F. Doyon. 2018. Silviculture for Eastern Old Growth in the Context of Global Change. Pages 237-265 in Barton, A.M. and W.S. Keeton. Ecology and Recovery of Eastern Old-Growth Forests. Island Press, Washington, DC.

Larson, A.J., J.A. Lutz, R.F. Gersonde, J.F. Franklin, and F.F. Hietpas. 2008. Potential site productivity influences the rate of forest structural development. Ecological Applications 18 (4), 899-910.

Luyssaert, S., E.D. Schulze, A. Börner, A. Knohl, D. Hessenmöller, B.E Law, P. Ciais, and J. Grace. 2008. Old-growth forests as global carbon sinks. Nature 455(7210):213-215.

Mehl, M. S. 1992. Old-growth descriptions for the major forest cover types in the Rocky Mountain Region. In: Old growth forests in the Southwest and Rocky Mountain Regions. Gen. Tech. Rep. RM-213. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. Rocky Mountain Forest and Range Experiment Station.

Odum, E.P. 1969. The Strategy of Ecosystem Development: An understanding of ecological succession provides a basis for resolving man's conflict with nature. Science 164(3877):262-270.

Oliver, C.D. and B.C. Larson. 1990. Forest Stand Dynamics. McGraw-Hill, Inc. New York, NY.

Spies, T.A. and J.F. Franklin. 1991. The structure of natural young, mature, and old-growth Douglas-fir forests in

Oregon and Washington. Pages 91-109 in Ruggiero, L.F., K.B. Aubrey, A.B. Carey, and M.H. Huff (eds.): Wildlife and vegetation of unmanaged Douglas-fir forests. USDA Forest Service, General Technical Report PNW-285.

Tyrell, Lucy E.; [and others]. 1998. Information about old growth for selected forest type groups in the Eastern United States. Gen. Tech. Rep. NC-197. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Experiment Station. 507 p.

U.S. Department of Agriculture, Forest Service. 1989. Position statement on national forests old-growth values. Unnumbered internal memo to regional foresters, station directors, and Washington Office staff, October 11, 1989. On file with: U.S. Department of Agriculture Forest Service Auditors Building 201 14th Street, S.W. at Independence Ave., S.W. Washington, DC 20250.

Various authors. 1993. Interim old growth definitions for Douglas-fir, grand fir/white fir, interior Douglas-fir, lodgepole pine, Pacific silver fir, ponderosa pine, Port Orford-cedar and tanoak, subalpine fir, and western hemlock series. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 124 p.

Wirth, C., C. Messier, Y. Bergeron, D. Frank, and A. Fankhänel. 2009. Old-growth forest definitions: a pragmatic view. Pages 11-33 in: Wirth, C., G.Gleixner, and M. Heimann (eds). Old-Growth Forests. Ecological Studies, vol 207. Springer, Berlin, Heidelberg.