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Assessing the short-term impacts of variable retention harvesting (VRH) and climatic drivers on carbon sequestration and growth of a red pine (Pinus resinosa) plantation in southern Ontario, Canada

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Variable retention harvesting (VRH) is a silvicultural management practice that has been utilized to promote biodiversity, growth, and carbon sequestration in managed forests. VRH has been implemented as a climate mitigation strategy in response to increased climate warming and more erratic precipitation patterns which are occurring due to anthropogenic production of greenhouse gases. The aim of this study is to determine the impact of VRH and climate change on the inter-annual growth and carbon sequestration in a 20 ha red pine (Pinus resinosa) plantation forest located in southern Ontario, Canada over a 5-year period (2014-2018). The VRH treatment was implemented in 2014 within twenty, 1-hectare plots, which were subjected to one of four experimental thinning treatment types; 33% and 55% crown retention in an aggregated pattern (33A and 55A, respectively); and 33% and 55% crown retention in a dispersed pattern (33D and 55D, respectively), while four plots were maintained as unharvested control (CN) plots. In each plot, approximately sixty 5 mm increment cores were collected from residual trees during the spring and summer of 2019. These cores were processed for annual incremental growth according to standard dendrochronological methods to identify the climatic drivers on growth. Biomass and carbon sequestration were estimated using a species-specific allometric growth equation to quantify the impact of the different VRH treatments on red pine growth. Results of climate-growth assessments indicate that red pine growth in this region is dependent on maximum temperatures and total precipitation during the summer growing season. These relations were best captured in the May-July standard precipitation evapotranspiration index with a 3-month memory (SPEI3). May to August average maximum temperature and May to June total precipitation are also important drivers of red pine growth in all plots. We found that the dispersed crown retention patterns are the only VRH treatments that result in an increase in post-harvest growth; 8.12 ± 9.83% increase for 33D and 7.52 ± 5.71% increase for 55D. This suggests that dispersed retention may spatially optimize growth for the climatic conditions and be best suited for managing these forests under changing climatic conditions in the future. Aggregated treatments are found to have significantly less growth post-harvest; 33A had an average of 0.34 kg less biomass post-harvest (2.50 ± 1.94% decrease) and 55A had an average of 0.44 kg less biomass post-harvest (6.36 ± 3.82 % decrease). Our control sites showed that post-harvest growth showed an average of 0.56 kg less biomass

post-harvest (6.01 ± 3.39% decrease). Within the aggregated treatments, exterior trees demonstrated increased growth, annual biomass accumulation, and carbon sequestration compared to trees growing in the interior of the aggregated plots. Our results suggest that dispersed crown retentions are most optimal when the goal of VRH is to increase growth or carbon sequestration. This research is ultimately important in informing future forest management practices in similar plantation forests across southern Ontario and elsewhere in the Great Lakes region and northeastern North America.