CMER/Policy Interaction Framework Six Questions
Riparian Extensive Vegetation Monitoring - Model Transferability Testing
March 16, 2020

1. **Does the study inform a rule, numeric target, performance target, or resource objective?**

   No, the study does not inform any specific rule, numeric target, performance target, or resource objective.

   This study informs the accuracy and transferability of the LiDAR models developed in this study for assessing riparian forest conditions among different stand types. Understanding prediction accuracy is essential for assessing the level of scientific confidence that can be obtained from a statewide riparian status and trends monitoring (i.e., extensive monitoring) program.

   This study was intended to be quick in order to use FY2019 unspent CMER funds, and a part of that speed was based on using existing plot data. However, more rigorous work in designing the plots and placing them on the landscape would remove plot design and sampling limitations as factors in model accuracy changes.

2. **Does the study inform the Forest Practices Rules, the Forest Practices Board Manual guidelines, or Schedules L-1 or L-2?**

   No, not directly. This study tested the performance of model transfereability that could potentially be used for implementing a regional or statewide status and trends monitoring (i.e., extensive monitoring) program to measure the short and long-term condition of riparian forests managed under the forest practices rules covered under the Forest Practices Habitat Conservation Plan (FP HCP). Status and trends monitoring is part of the Extensive Monitoring Program in the 2019 CMER Work Plan.

3. **Was the study carried out pursuant to CMER scientific protocols (i.e., study design, peer review)?**

   No. There was no formal scoping process (i.e., best available science, Alternatives analysis) of the Riparian Extensive Monitoring–Model Transferability Testing project as outlined in the Cooperative Monitoring Evaluation and Research (CMER) protocol and standards manual guidelines. The study was not submitted for Independent Scientific Peer Review (ISPR), but was reviewed by the Riparian Scientific Advisory Group (RSAG) and CMER. CMER decided to defer ISPR because this is an exploratory report that would be submitted to ISPR along with a riparian forest monitoring design when and if Timber Fish and Wildlife Policy (Policy) and the Forest Practices Board (Board) decide to fund a future state-wide or regional riparian vegetation monitoring component of the CMER's Extensive Riparian Vegetation Status and Trends Monitoring Program.

4. What does the study tell us? What does the study not tell us?

What does the study tell us?

The objective of this project is to test the transferability of several forest inventory models developed in the Mashel watershed under the "Extensive Riparian Vegetation Monitoring - Remote Sensing Pilot Study Agreement No. IAA 16-205". The transferability of Mashel models to predict DBH, basal area, and stand density were tested using forest inventory plots that were established in the Olympic Experimental State Forest (OESF).

The performance of all Mashel models decreased when applied to the OESF plots, except for the existing diameter model when used on the full OESF plots, which performed equally as well. The existing density model when used on the full OESF plots had only a slight decrease in performance. Refitting and adapting the models improved performance for all models, but still did not achieve the accuracy of the Pilot Study, except for the existing diameter model and the existing density model when used on the full OESF plots.

The study found that native models (i.e., models that were developed in a specific forest type and used to predict stand characteristics in that same forest type) performed in line with expectations. For example, the native Mashel model is relatively good for predicting basal area and diameter, but poor for predicting density of riparian stands within the Mashel basin. Similarly, the OESF model perfomed well for predicting all stand metrics for stands within the OESF. However, the performance of both native models decreased when applied to stands in the other forest type (Table 1).

The study indicates that transferring models between forest types can have large impacts on model accuracy. The forests in the Mashel (West Cascades) and OESF (Olympic Coast) are very different, and it was expected that there would be a decrease in model accuracy. This study demonstrates the scale of that decrease, and also makes clear that different inventory models will be required for different forest types in a statewide monitoring effort. Also, the study findings indicate directly applying inventory models from the Mashel to the OESF or from the OESF to the Mashel should only be done with great care and caution.

There are a number of factors that influenced the ability to test the model transferaibility in this study that need further investigation (eg. uniformity of plot size, location, and configuration).

Table 1. Summary of results from final report tables 16, 17, and 19 of model performance and transferability for Mashel and OESF models.

Coefficients of Determination (r^2)*

Native Location Forcast Location	Mashel Mashel	OESF OESF	Mashel OESF	OESF Mashel
Basal Area	0.72	0.61	0.32	0.68
Density	0.46	0.71	0.44	0.17
Diameter	0.70	0.86	0.70	0.58

*The coefficient of determination is a measure of model performances and ranges from zero to one, with zero meaning that the model cannot predict any of the variance in the forcast location, and one meaning that the model can predict all of the variance in the forcast location.

What does the study not tell us?

The data suggests that directly applying inventory models from the Mashel to the OESF or from the OESF to the Mashel should only be done with great care and caution. There will be noticeable decreases in accuracy in most circumstances.

For a model to be transferable to a new forest type, it must be useable without collecting new plot inventory data, and should achieve accuracies as good as models developed in that new forest type.

For the purposes of this study, that means that in the OESF, the existing Mashel models should achieve accuracies as high as the new OESF models. Comparing existing Mashel model accuracies to new OESF model accuracies (Table 17 and Table 18 in final report) shows that this did not occur. Additionally, for the Mashel plots, we would expect to see the new OESF models (Table 19 and Table 20 in final report) achieving the same accuracies as the Mashel models did in the pilot study (Table 16 in final report).

This study does not tell us how many distinct forest types need to be considered for statewide riparian vegetation monitoring or how many inventory models may be necessary for predicting stand characteristics for each distinct forest type. To assess future modeling needs, input from decision makers will be necessary to determine what levels of model accuracy are acceptable. If lower model accuracies are acceptable, it is likely that fewer models will need to be developed, and vice versa.

The Pilot Study and other work in the literature have demonstrated that LiDAR is a useful tool for estimating some of the 13 inventory metrics and not for others. It will be critical to identify inventory attributes that are “must haves” for riparian vegetation monitoring, with the realization that LiDAR may not be the tool to estimate some of them. For certain metrics, like height and canopy cover, LiDAR is the best tool available.

5. **What is the relationship between this study and any others that may be planned, underway, or recently completed?**

Extensive Riparian Vegetation Monitoring has the potential to provide the spatial context for better understanding the distribution of riparian stand conditions across a highly variable landscape. This may also further inform Policy and the Board about other CMER studies that test the effects and validation of forest practices rules on FP HCP lands. A state-wide extensive monitoring program for riparian vegetation could inform or be informed by the Westside Type F Riparian Prescription Effectiveness Study, Riparian Characteristics and Shade Study and other Extensive Riparian Status and Trends Temperature Monitoring projects.

The Remote Sensing Pilot study was the remote sensing tool development phase of the Extensive Riparian Vegetation Monitoring Program, and it was completed in June 2017. It was based on a literature synthesis that was completed in November 2015. The first phase was the first Remote Sensing Pilot study, carried out in the Mashel watershed, which evaluated the relative effectiveness, accuracy, and cost of using LiDAR and aerial imagery to assess riparian stand conditions. The Implementation Pilot Study completed in June 2018 further refined a study design that was articulated in the literature synthesis and evaluated in the first Remote Sensing Pilot.

Inventory models for different forest types will be necessary. How many is still unknown. Further work needs to be done to better understand the number of models that will be necessary for statewide monitoring. This will involve installing forest inventory plots in additional forest types, and also looking at the types of models being used. Eastern Washington is the area of the state that should be prioritized for new plot installation.

Because the linear regression models presented here are dependent on the selected LiDAR metrics and the values of those metrics, it could be valuable to examine whether or not there are certain LiDAR metrics that consistently appear in models in different forest types. If specific metrics are present in some of the best models across forest types, those metrics may be worth using even if it reduces model accuracy in some locations.

The next phase of this project was developed as part of SAGs submitting projects to CMER for potential use of unspend funds meeting specific criteria, one being that funds would need to be expended and projects completed by the end of this biennium (2021). If funded, this project would continue testing the Mashel watershed riparian forest model using LiDAR and field data collected by DNR in a watershed in the Olympic Experimental State Forest (OESF). This project would build upon this work.

This project is proposed to be implemented in four steps which should occur in sequential order but can be completed as separate phases as funding is available:

1) Summarize existing plot and LiDAR data and test two modelling approaches: 4.5 months

2) Develop enhanced database with additional modeling approaches: 3 months
3) Develop Model Validation Plan: 1.5 months
4) Model Validation: 7 months

A starting point for those forest types could be those used by the Washington Department of Natural Resources forest inventory group, EPA Ecoregions, USDA Forest Service Ecological Subregions, or the Franklin and Dyrness Generalized Vegetation Map of Oregon and Washington. Having inventory plots present in all forest types will be needed to determine how many models will be needed.

Although LiDAR is a very powerful tool, other technologies such as stereo satellite or aerial imaging and new developments in analyzing these data sources should continue to be followed as a potential alternative for long-term monitoring in place of multi-date LiDAR data. These data could be used to compare and monitor the trends in the riparian forest conditions once a LiDAR-based baseline has been established. Extensive Riparian Vegetation Monitoring is a long-term undertaking and will require a long term budget strategy that funds the ongoing monitoring (e.g. annually or periodic survey) well into the future.

6. What is the scientific basis that underlies the rule, numeric target, performance target, or resource objective that the study informs? How much of an incremental gain in understanding do the study results represent?

Extensive monitoring is one component of three distinct monitoring programs (Effectiveness, Extensive, and Validation monitoring) outlined in the 2019 CMER work plan for assessing the overall effectiveness of the forest practice rules and status and trends in riparian stand conditions over time. Extensive monitoring is a population-scale assessment of the status and trends of riparian stand conditions where forest practices rules have been applied on forestlands. Four areas for extensive monitoring are outlined in the 2019 CMER work plan: stream temperature and riparian stand characteristics, barriers to fish passage, forest roads, and mass wasting.

As stated in the 2019 CMER work plan, "Extensive monitoring programs evaluate the current status of key watershed input processes and habitat condition indicators across FP HCP lands, and document trends in these indicators over time as the forest practices prescriptions are applied across the landscape. Extensive monitoring provides a statewide, landscape-scale assessment of the effectiveness of forest practices rules to attain specific performance targets on FP HCP lands. Extensive monitoring is designed to provide report-card-type measures of rule effectiveness (i.e., to what extent are FP HCP performance targets and resource condition objectives being achieved on a landscape scale over time). These measures can then be used to determine the degree to which progress is meeting expectations."