Use of Remote Sensing to Conduct Extensive Riparian Monitoring

From the Cooperative Monitoring Evaluation and Research Riparian Scientific Advisory Group February 12, 2014

Purpose

The Riparian Assessment Science Advisory Group (RSAG) of the Cooperative Riparian Evaluation and Research Committee (CMER) was asked by the Timber Fish and Wildlife Policy Committee (Policy) to provide a "high level" assessment on moving towards using remote sensing to conduct the Extensive Monitoring Program established in the CMER workplan.

Specifically, "*Policy directed RSAG to consider high-level options for how to move forward on extensive monitoring as well as options for other extensive studies. This should include perspectives considering the past and future as well as existing technologies. RSAG should also consider other monitoring approaches to landscape-level performance*" (July 11, 2013 Policy meeting notes).

Discussion

RSAG has had numerous conversations over the years about the potential use of remote sensing technologies to conduct extensive (status and trends) monitoring. The lack of clear status and trends performance targets or more specific Policy questions has resulted in no changes being proposed to the current program strategy outlined in the CMER Work Plan. Policy has yet to provide the level of detail necessary for RSAG to provide a detailed comparative assessment of the merits and costs of replacing field monitoring with remote sensing data.

To help facilitate this discussion for Policy, CMER has provided a table (Table 1) with examples of potential questions that Policy may be interested in answering as part of status and trends monitoring. These questions are examples only, and the table should not be misinterpreted as CMER attempting to form such Policy questions.

In addition, RSAG has focused on the root elements of the last recorded Policy request (above) and past experience (limitations) conducting field data collection/measurement of temperature monitoring.

RSAG is operating from the principal assumption that Policy and the Board want an extensive monitoring program that will provide an unbiased assessment of trends (change over time) in temperature and riparian vegetation since enacting the forests and fish report (FFR) through the state's forest practices rules.

Following CMER's remote sensing science session (November 2013) RSAG's conclusions regarding extensive monitoring in general, and the use of remote sensing as a potential alternative, can be summarized as follows:

1. On-the-ground monitoring of stream temperature is necessary to obtain reliable in-stream temperature data. However, due to the following issues it may not satisfy key goals of the extensive monitoring program as outlined in the FP HCP because of:
    a. lack of access prevents a spatially representative and unbiased sample (very few SFLO sites and limited access to all large landowner sites).
    b. unavailability of a suitable in-stream temperature data set representing temperature patterns at the start of FFR implementation (2001).
2. There is a direct trade-off between the precision and accuracy of the measurements:
    a. On-the-ground field monitoring provides the most accurate and detailed data but cannot be employed across the landscape without site selection bias (due to limited landowner participation).
    b. A combination of multi-spectral imagery and LiDAR provides the highest resolution remote sensing data and allows greater geographic coverage (number or density of sites) then on-the-ground field monitoring. However, LiDAR is not currently available across the FFR landscape and would need to be acquired and analyzed.
    c. Historic Landsat and NAIP photogrammetry provides moderate resolution of riparian characteristics and a coarse ability to distinguish stream type. Although the imagery already exists, resources would still need to be used to analyze the photos and extract the data.
    d. All remote sensing requires some calibration using field measurements across the assessed landscape in order to maximize its unique potential of resolution.
3. Full implementation of FFR rules began in 2001 and much change has likely already occurred:
    a. Existing research and experience suggests that much of the initial benefits (e.g. increased canopy coverage on Type Np waters) to the FFR changes will have occurred in the first decade.
    b. Neither adequate extensive monitoring field data (e.g. in-stream temperature) nor high resolution remote sensing data (e.g., LiDAR) are available for the period of time from the present back to the full implementation of the FFR riparian prescriptions.
4. Extensive monitoring cannot assign causality (unlike effectiveness monitoring) regardless of the method of data collection:
    a. Extensive monitoring cannot determine if forest practices are the cause of any trends observed in general (e.g. stream temperature).
    b. Extensive monitoring will not inform how any prescriptions may need to change to alter an unsatisfactory trend.
5. If designed properly, Extensive monitoring can quantify how riparian stands are changing over time across the landscape since full implementation of the FFR rules. For example, extensive monitoring may be use to measure:
    - proportion of riparian stands on trajectory to DFC
    - changes in seral stage
    - changes in conifer/broadleaf dominance patterns
6. The Adaptive Management Program will need to continue to rely on the effectiveness monitoring studies to determine the effect of specific prescriptions (such as vegetative buffers) on the aquatic and riparian resources:

a. The nexus between extensive and effectiveness monitoring would be based on the assumption that same results observed in CMER's effectiveness research studies would occur on all sites on the landscape with grossly similar riparian buffer conditions.

Policy Options

Considering the principle purpose of the extensive monitoring program (detecting status and trends), a potential course of action would be to replace on-the-ground field measurements with remote sensing using NAIP or Landsat photogrammetry. However, there are many technical issues with implementation that will determine what products can be provided to Policy. For example, the Type F stream network is delineated on the hydrolayer, however, assigning a category to the buffer along any given reach is complicated by the rules. Potentially, there could be three drastically different vegetation types for the Core, Inner, and Outer zones of the buffer at any given point on the stream. Even a simple metric like buffer width may be difficult to discern accurately (some portions of the outer zone may be harvested) and any metric derived will likely be very simplistic or imprecise, or both.

Although Type N streams have a simpler buffer strategy, the Type N portion of the hydrolayer contains many errors in the form of: a) depicting streams that don't exist on-the-ground, b) streams that exist on-the-ground but are not depicted on water type maps, and c) inaccurate locations of streams and their upper most points of a perennial flow. To minimize these potential sources of error may require field visits to verify the stream type, which may nullify some of the benefits of remote sampling.

Adopting a remote sensing option would result in the loss of the in-stream temperature status and trends component of the extensive monitoring program. However, as stated above, CMER currently has not had success monitoring stream temperatures or riparian conditions on forest lands owned by small forest landowners, which make up nearly half of the FFR landscape. Dropping on-the-ground measurements would also mean accepting a coarser level of resource assessment then would be provided under our current design which mainly relies on field crews for data collection, or with using more advanced methods of remote sensing. What is gained in exchange (benefit), however, is the ability to cover all of the FFR regulated landscape using an unbiased sampling network, and to estimate the base line condition that existed prior to the implementation of forest practices rules under FFR. With assistance from CMER, the Timber Fish and Wildlife Policy Committee will need to determine if these tradeoffs are sufficiently balanced to warrant moving forward with any change to the extensive monitoring program.

RSAG urges the TFW Policy Committee, and the Board if necessary, to carefully assess and discuss what type and resolution of data and what amount of change in riparian conditions would be useful in the adaptive management program. As stated previously, the current design of the extensive monitoring program cannot detect causality. It is the effectiveness monitoring projects which are designed to detect causality. The accuracy of various parameters measured remotely (e.g., height, density, dfc, buffer width) varies widely and the trends over time may not change consistently with one another. What would be the Policy and Board response to such trends should they occur? How does this data/ information relate to what's required under CWA assurances and other federal requirement under the FP HCP? Is trying to gather such information the most efficient use of CMER's resources?

Substantial technical issues will need to be resolved to implement any of the remote sensing approaches in an extensive monitoring program. Implementing any combination of these approaches will require substantial human and financial resources.

These types of questions and considerations should be further explored by Policy, and the Board if need be, before considering alternatives to CMER's existing approach.

Table 1. In order to determine the specific metrics and remote sensing methodology for extensive monitoring we need to have clearly defined monitoring objectives. The monitoring objectives are directly dependent on the Policy defined questions and performance targets. Below are examples that show the range of potential policy relevant riparian management questions, policy performance targets/triggers, and CMER monitoring objectives.

Policy Questions	Timing or Duration	Policy Performance Target/AM Trigger (options)	CMER Monitoring Objective	Level of Resolution
1. What is the proportion of F and N streams with buffer strips?	Current (status)	Standing timber (e.g., trees dominate over shrubs/ground) within x distance. Stand structure within x distance (e.g., conif-decid; young-mature; sparse-dense)	Detect presence/absence of performance target within buffer zone boundary	Assumes any strip of trees (>10yrs age) along a stream (seen in photos or on hydrolayer) represent a forested buffer.
2. What is proportion of F-buffers that are on trajectory to DFC (Westside)?	Current (status)	Stands at DFC by map site class	Assess stand composition (i.e., species, height, density) by site class	Uses estimated height and standard tables to estimate age, dbh, ba, and tpa. Uses Organon and average dbh to estimate DFC. Only trees that can be visually separated in photos can be used.
3. What is proportion of F-buffers that are on trajectory to DFC (Eastside)?	Current (status)	Eastside riparian stands are on a progression towards attaining natural fire disturbance regime conditions.	Assess stand composition (i.e., species, height, density) by site class. Determine extent of stands that meet management objectives for tpa and ba for eastside forests.	Will use estimated height and standard tables to estimate age, dbh, ba, and tpa. Only trees that can be visually separated in photos can be used
4. Is the proportion of F and Np buffers increasing over time.	Long-term (10-yr	All F-stream buffers have standing timber by 2015. All F-stream buffers are dominated by conifer.	Detect trend over time (e.g., change in proportion of stands that meet performance target	Simple change in proportion of linear treed regions along stream margins.

	intervals)	At least 50% of Np stream length buffered	since start of FFR rules;2000)	
5. Is the proportion of F-buffers that are on trajectory to DFC increasing (Westside)?	Long-term (10-yr intervals	All At least 50% of F-buffers on trajectory to DFC	Detect trend over time (e.g., change in proportion of stands that meet performance target since start of FFR rules;2000)	Will use estimated height and standard tables to estimate age, dbh, ba, and tpa. Will use Organon to estimate DFC. Only trees that can be visually separated in photos can be used.
6. Is the proportion of F-buffers that are on trajectory to DFC increasing (Eastside)?	Long-term (10-yr intervals	Eastside riparian stands represent natural fire disturbance regime conditions.	Detect trend over time (e.g., change in proportion of stands that meet eastside inner zone entry requirements.	Will use estimated height and standard tables to estimate age, dbh, ba, and tpa. Only trees that can be visually separated in photos can be used
7. Is the proportion of hardwood dominated stands changing over time.	Long-term (10-yr intervals	HCP intends to convert hardwoods to conifer.	Detect trend over time (e.g., change in proportion of stands dominated by hardwoods.	Will use change in crown composition and area.

Table 2. Program Research Questions from the CMER workplan developed to respond to the Extensive Monitoring Program Rule Group Critical Question: "What is the current status of riparian conditions and functions in [*Type N*] / [*Type F and S*] streams on a regional scale, and how are conditions changing over time?"

Number	Program Research Question	Benchmarks
1	*What is the distribution of maximum summer stream temperature and 7day mean maximum daily water temperature on FP HCP lands, and how is the distribution changing over time as the forest practices prescriptions are implemented?*	*RSAG has used 16°C as a benchmark since it is a common water quality criterion for forested streams in Washington.*
2	*What proportion of stream length on FP HCP lands meets specific benchmarks for water temperature, and is this proportion changing over time as the forest practices prescriptions are implemented?*	*RSAG has used 16°C as a benchmark since it is a common water quality criterion for forested streams in Washington.*
3	*What are current riparian stand attributes on FP HCP lands, and how are stand conditions changing over time as the forest practices prescriptions are implemented?*	***No riparian attributes have been specified**. Is the goal to track riparian stand attributes which relate to stream productivity, i.e. that support/provide (1) shade, (2) large wood delivery, (3) bank stability, and (4) nutrients? Are riparian stand attributes needed only as covariates to help explain temperature patterns? If so, which ones are most appropriate? Is the goal to estimated rates of windfall in the riparian areas? Is the goal to track landscape patterns in riparian broadleaf/conifer distributions?*
4	*What proportion of westside Type F/S stream length on FP HCP lands meet DFC basal area performance targets, and how is the proportion changing over time as the forest practices prescriptions are implemented?*	*A DFC target has been established by rule for the Westside.*
5	*What proportion of eastside Type F/S stream length on FP HCP lands are within the eastside basal area ranges, and how is the proportion changing over time as the forest practices prescriptions are implemented?*	***No clear targets for trends specified**.* Should the BA targets used to condition harvest by vegetation zone be used as both status and trend targets? If not, what would be the target or parameter for trend detection?

Table 3. The choice of method depends in large part on what Policy and the Board needs to know. The following table provides examples of some key issues of inquiry and how they affect the choice of method.

Policy Relevant Question	Affect on Monitoring Method Decision
Does Policy need a random spatially representative assessment of status and trends?	If yes, then we need to use remote sensing. Most small forest landowners and some large landowners deny access.
Does Policy need to know vegetation trends since 2001(FFR)?	If yes, then we need to use remote sensing using NAIP or Landsat imagery since this imagery is all that is available for the period.
Does Policy need temperature trends since 2001(FFR)?	If yes, then no option exists.
Does Policy need temperature trends going forward from the present time?	If yes, then we need to use on-the-ground field sampling.
Does Policy want to know DFC trends westside?	If yes, an accurate estimate would require field measurements, and remote sensing would produce decreasing levels of accuracy as resolution decreases from LiDAR, to NAIP, and to Landsat. Status and trends estimates intended to represent the effect of specific prescriptions will almost certainly require both on-the-ground field sampling as well as prior knowledge of the choice of harvest strategy employed.
Does Policy want to know DFC trends eastside?	If yes, then 1) a decision must be reached on what metric(s) and values will be used to represent DFC on the eastside, and 2) the level of accuracy desired will need to be determined by Policy. DFC on the eastside is by design a shifting mosaic of species and basal areas with the choice of management based on elevation-based vegetation zones. An accurate estimate would require field measurements, and remote sensing would produce decreasing levels of accuracy as resolution decreases from LiDAR, to NAIP, and to Landsat. Status and trends estimates intended to represent the effect of specific prescriptions will almost certainly require both on-the-ground field sampling as well as prior knowledge of the choice of harvest strategy employed