USING REMOTE CAMERAS TO MONITOR THE EFFECTIVENESS OF CARIBOU HABITAT RESTORATION

Summary Report from the May 28, 2021 Workshop on Remote Cameras
Hosted by the Habitat Conservation Trust Foundation

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HABITAT CONSERVATION TRUST FOUNDATION

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Dear Reader,

Thank you for your interest in this report. It was commissioned by the Habitat Conservation Trust Foundation (HCTF) and the contractors' recommendations are currently under review. They do not represent program administration decisions at this time. HCTF will be considering these recommendations as we update program guidance documents in preparation for future Caribou Habitat Restoration Fund (CHRF) application intakes. More information can be found on our website at https://hctf.ca/grants/caribou-habitat-restoration-grants/ .

Sincerely,

Dan Buffett
CEO
Habitat Conservation Trust Foundation

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ACKNOWLEDGEMENTS

This report summarizes findings and outcomes from a half-day virtual workshop on the use of remote cameras to monitor the effectiveness of caribou habitat restoration. The workshop was held on May 28th, 2021, hosted by the Habitat Conservation Trust Foundation. We wish to recognize a large contribution by Shannon West at the Foundation to address the administrative challenges with the workshop. We extend thanks to the following participants for their valuable input during the workshop:

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INTRODUCTION

Caribou (*Rangifer tarandus*) is an iconic wildlife species in BC that is currently designated as threatened (boreal, central mountain and southern mountain populations) or at risk (northern mountain populations) due to population declines and range retraction throughout much of its distribution. Population declines are largely attributed to anthropogenic disturbances occurring within and adjacent to caribou range. To address factors contributing to population declines and aid caribou recovery, the provincial government initiated the Caribou Recovery Program (CRP). A key component of the CRP is the restoration of caribou habitat that has been adversely affected by human-caused disturbances. To administer this component of the CRP, the Province has provided resources to the Habitat Conservation Trust Foundation (HCTF) to implement the Caribou Habitat Restoration Fund (CHRF). This program manages funding for projects aimed at restoring high-value habitat for caribou within various areas of the province. Inherent to this management is ensuring that resources are used effectively and efficiently to restore caribou habitat. To that end, the CHRF requires project proponents to submit proposals that include a monitoring program to help assess the effectiveness of the proposed works. The CHRF, however, is seeking an approach to deal with the challenge of guiding proponents to monitoring techniques that are robust and achieve the program's objectives.

CHALLENGES TO MONITORING CARIBOU HABITAT RESTORATION

Because caribou habitat restoration is an emerging and evolving field, a key uncertainty is determining the effectiveness and cost-efficiency of the various restoration techniques used to date. Currently, the CHRF recognizes the need to implement both ecological and functional restoration projects. Ecological restoration uses techniques that aim to restore areas to their pre-disturbed state. These techniques include soil decompacting, soil mounding and tree planting. Functional restoration uses techniques that aim to alter human and/or wildlife behaviour to ultimately restore historic encounter rates between caribou and their predators. Compared to ecological restoration, functional restoration may not result in treated areas returning to their pre-disturbance state. However these techniques are anticipated to have a more immediate effect on the biological processes affecting caribou population decline (e.g., altered caribou-predator dynamics), potentially helping to reduce caribou mortality in the short-term.

Evaluating the effectiveness of caribou habitat restoration generally requires monitoring how vegetation structure, human use, and/or wildlife use changes in the restored area through time. Note that the results of ecological restoration, and some functional restoration efforts, may take years or even decades to achieve project objectives and to ultimately contribute to caribou recovery. For the latter goal, impacts from an individual project on caribou recovery may be difficult to assess because of the large spatial scales (e.g., restoring a significant proportion of caribou range) and temporal scales (e.g., the time required to restore old-growth conditions preferred by caribou) needed to effectively change caribou demography.

In general, proponents of CHRF projects have used a multi-objective approach for monitoring the effectiveness of caribou habitat restoration. For those projects focusing on ecological restoration, monitoring the vegetation response is a primary objective and in recent years frameworks have been developed by provinces—or are in the process of being developed—to guide proponents on how to effectively monitor vegetation in the context of caribou habitat restoration (e.g., the *Operational Restoration Framework: Woodland Caribou Habitat Restoration in British Columbia* [draft; BC Ministry of Forests, Lands and Natural Resource Operations, and Rural Development 2021]; the *Provincial Restoration and Establishment Framework for Legacy Seismic Lines in Alberta* [draft; Government of Alberta 2018]). For many ecological restoration projects, and all functional restoration projects, proponents have also developed monitoring frameworks to assess changes in human and wildlife behaviour. These objectives are included within their monitoring frameworks because changes in vegetation or geophysical structure (e.g. soil decompaction and mounding) are expected to alter human and wildlife behaviour within the restored area (e.g. Pigeon et al. 2016, Dickie et al. 2017, Dickie et al. 2021) and these changes may provide a more direct and shorter-term link to infer potential changes in caribou-predator dynamics. However, monitoring wildlife responses to restoration is challenging because many of the focal species (e.g., wolves, caribou) occupy the treatment area at low density, which makes it difficult to discern whether potential changes in wildlife behaviour can be attributed to the restoration treatment(s).

Over the last decade, remote camera traps have become increasingly used to monitor wildlife (Burton et al. 2015). Potential advantages of remote cameras compared to other monitoring techniques are they are less invasive (cf. animal capture and radio-collaring), more cost-effective (cf. repeated aerial surveys), and can monitor the responses of multiple species simultaneously. As a monitoring tool, remote cameras can provide estimates of relative use, occupancy, and abundance (or density), though their efficacy in providing reliable estimates of these metrics is highly dependent on study design (Burton et al. 2015, Kays et al. 2020). If careful consideration is not given as to how cameras are deployed, the resulting data may yield unreliable or misleading estimates of the monitoring metric, which therefore diminishes their efficacy and cost-effectiveness as a monitoring tool. To date, the use of remote cameras for monitoring the effectiveness of caribou habitat restoration has been limited to a few studies (e.g., Tattersall et al. 2020, Dickie et al. 2021, Keim et al. 2021) and there exists considerable uncertainty as to how remote cameras should be used to monitor the effectiveness of habitat restoration. This uncertainty is reflected in the variety of remote camera sampling designs contained across current and proposed CHRF projects.

To address the challenges associated with remote cameras as a monitoring tool within caribou habitat restoration projects, HCTF hosted a half-day workshop on May 28, 2021. Workshop invitees included HCTF representatives, government biologists, practitioners of caribou habitat restoration and researchers with expertise in remote camera studies. Key objectives of the workshop were to determine whether remote cameras are an effective, cost-efficient tool for monitoring caribou habitat restoration and, if so, to develop a consistent approach for deploying cameras to evaluate restoration effectiveness.

SUMMARY OF WORKSHOP OUTCOMES

EXPERIENCE OF PRACTITIONERS

The workshop began with practitioners detailing their experiences using remote cameras as a monitoring tool. Practitioners identified three primary reasons for deploying remote cameras:

1. To monitor for potential changes to the vegetative and structural condition of restoration actions or treatments
2. To monitor for potential changes in human use of the restored area
3. To monitor for potential changes in wildlife use of the restored area

Monitoring the Condition of Restoration Actions
Practitioners described using remote cameras to monitor the integrity of deployed actions or treatments over time. In general, this type of monitoring focuses on determining the degree to which functional restoration treatments (e.g., barriers blocking access and limiting movement) remain intact (i.e., in a structural state similar to at installation) and for how long. For this purpose, cameras were typically deployed near access points to the restored area and/or on particular restoration features.

Monitoring Human Use
Remote cameras were also used to monitor how functional restoration affects human use and behaviour. Practitioners reported that changes in human use and behaviour (e.g., ATV use, hunter foot traffic) were relatively easy to detect with cameras, in contrast to the weak signals detected by cameras when used for monitoring wildlife (see below). This difference may reflect that functional restoration techniques are more effective at limiting human use of restored areas than they are at limiting wildlife use. From a practical standpoint, the large effect sizes associated with human behavioural changes resulted in these changes being detectable even with a small number of cameras and/or limited monitoring time. Nevertheless, pre-treatment monitoring, preferably for a duration of at least one year, was necessary to evaluate for changes in human behaviour.

Similar to monitoring for the condition of restoration actions, monitoring for human use and behaviour generally involved placing cameras at access points to the restored area. Thus, in many situations, monitoring human use and the condition of restoration actions can likely be accomplished simultaneously.

Monitoring Wildlife Use
A primary objective for using remote cameras in restoration projects was to monitor for changes in wildlife use and behaviour. In most instances, predators of caribou such as wolves and bears were the focus of monitoring. Disturbances, particularly linear ones such as roads and seismic lines, are thought to facilitate predator movements into caribou habitat, leading to

increased caribou-predator encounters and higher rates of caribou mortality (Dickie et al. 2017, DeMars and Boutin 2018, Mumma et al. 2018). This linkage to caribou demography makes predators a logical choice for monitoring if deployed treatments are aimed at limiting wildlife movement within the restored area.

Practitioners, however, reported significant challenges detecting change when monitoring predator behaviour. These challenges primarily related to low rates capturing predators on cameras, which confounds statistical inferences on potential behavioural changes. These challenges were even present in projects where a large number of cameras were deployed (e.g., >100; S.McNay, *personal communication*). For example, in a project in Alberta where 132 cameras were deployed, only 76 wolf occurrences were recorded over 33,600 camera-days of monitoring (M. Dickie, *personal communication*).

Non-caribou ungulates (e.g., moose and deer; hereafter, NCUs) were also included in monitoring efforts in some projects. Similar to predators, the monitoring of NCUs by cameras can be difficult due to low rates of occurrence (i.e., a low number of cameras with at least one picture of the focal species; Dickie et al. 2021). An additional challenge of NCU monitoring is the linkages among the type of treatment deployed, changes in NCU behaviour and caribou demography are less clear than those for predators. In general, changes in the abundance of NCUs are thought to affect caribou demography (Seip 1992, Serrouya et al. 2021), but cameras were primarily used to evaluate for changes in NCU use of the restored area. Although limiting use of disturbed areas by NCUs could limit their incursion into caribou habitat, NCUs are thought to use disturbed areas for forage-based reasons (i.e., increased forage availability; Peters et al. 2013, Finnegan et al. 2018) more so than for movement efficiency (but see Serrouya et al. 2017). For most functional restoration projects, treatments are deployed for movement-based reasons and less so for their effect on ungulate forage. Reducing sightability is an additional objective for some functional restoration projects. Ecological restoration may address forage-based mechanisms depending on the vegetation used. However, NCUs such as moose may use areas for 30 years post-disturbance (Mumma et al. 2021) and thus changes in distribution may not be evident during the shorter timeframes (i.e., 3 to 5 years) of CHRF projects.

Practitioners did not generally use caribou as a focal species for monitoring, presumably because their relative low number results in low rates of occurrence with the cameras. A few recent studies have included caribou in their monitoring framework, but these studies used ≥100 cameras (Dickie et al. 2021, Keim et al. 2021), which is generally far greater than the number of cameras deployed in CHRF projects. Notably, both studies monitored relative use of treated and control sites by caribou and did not monitor changes in caribou demography. Because of the large spatial scales of most caribou ranges and the comparatively small spatial extents of most restoration projects, using cameras to monitor changes in caribou demography (e.g., by estimating changes in abundance/density) is generally not feasible.

A further challenge reported by practitioners for a few projects was the initiation of wolf control after the deployment of restoration treatments. This management action confounds any inference on restoration effects on wildlife because wolf control not only affects the distribution and abundance of wolves, it also affects the distribution and abundance of ungulates and other predators.

Additional Comments

Outside of the challenges of effectiveness monitoring *per se*, practitioners also identified theft and damage of remote cameras as a key issue. Other logistical issues that were raised included potentially having to disturb restored sites when servicing the cameras and improper placement of cameras resulting in seasonal vegetation growth obscuring the camera's field of view and/or triggering the camera unnecessarily.

Remote Cameras as a Monitoring Tool: General Discussion

Practitioners' experiences directly informed a general discussion among workshop participants on the efficacy of remote cameras as a monitoring tool for caribou habitat restoration. When considering the three primary uses of cameras identified by practitioners, participants agreed that remote cameras are an appropriate tool for monitoring the physical and/or structural condition of restoration actions and monitoring changes in human use. For the latter, a key recommendation was to ensure that pre-treatment monitoring was conducted for an appropriate length of time (e.g. ≥1 year) to allow for robust before-after comparisons.

The remainder of the discussion primarily focused on the use of remote cameras for monitoring wildlife responses. These discussions first addressed whether remote cameras could provide inferences on wildlife response at the scale of an individual project then progressed to whether more robust inferences could be made by pooling data across multiple projects. For both scales, discussions focused on monitoring for changes in wildlife use of the restored area, rather than changes in occupancy or abundance/density as these metrics often have higher variability, which reduces the ability to make strong inferences on treatment effects. Also, detecting changes in these latter metrics would be even more difficult given the spatial and temporal scales typical of CHRF projects.

Monitoring Wildlife Response at the Individual Project Scale

Participants generally agreed that obtaining reliable inferences on wildlife response to restoration at the individual project scale is challenging. To obtain reliable inferences, projects would need to use a before-after design with pre-treatment (or "before") monitoring extending for at least 1–2 years, particularly if wolves were a focal species. HCTF representatives expressed concern with this monitoring time frame because project funding could not be guaranteed for that length of time (e.g. 4–5 years). Alternatively, if this length of pre-treatment monitoring cannot be accomplished, then a high number of independently-situated cameras (e.g., >60) would be required with some of these cameras potentially deployed at control sites with no restoration. A primary concern with this monitoring design is its high cost, which would divert a significant amount of funds towards monitoring and away from actually restoring caribou habitat. Moreover, many CHRF projects do not have the spatial extent to actually deploy >60 cameras that are independently-situated (e.g., > 1-km apart). Other designs are possible—for example, deploying cameras in an array to capture changes in movement speed (e.g., Dickie et al. 2020, DeMars and Bohm 2021)—but these designs also require a high number of cameras (e.g., 120 cameras for DeMars and Bohm 2021).

Monitoring Wildlife at the Multi-project Scale
To overcome the challenges of obtaining reliable inferences at the individual scale, one option to consider is pooling data across projects. Such pooling would increase overall sample sizes, which would increase the statistical power to detect changes in wildlife use. This approach, however, would require coordinating a high degree of standardization among projects, particularly if pre-treatment monitoring is limited (e.g. <1 year). These standards would include a protocol for where cameras are deployed (i.e., sampling design; Burton et al. 2015), how individual cameras are deployed (e.g., height, angle, field of view measurements), which can affect detectability (McIntyre et al. 2020), and requiring proponents to use the same brand and model of camera, because the performance of models can differ (Apps and McNutt 2018). Restoration treatments would also need to be standardized across projects. For ecological restoration, standards should include the species of vegetation used and stocking density. For functional restoration, standards of treatment intensity (e.g., number of trees felled per km) would be required, although such standards could be varied in a multi-site experimental design to assess treatment effectiveness and cost-efficiency. Note that this pooling and standardizing across projects does not remove the necessity of collecting sufficient pre-treatment monitoring data for each individual project.

Cost of a Monitoring Program with Remote Cameras
One proposed advantage of remote cameras is their cost efficiency relative to other monitoring methods. Costs of a reliable monitoring program, however, will vary with the monitoring objective. For monitoring the condition of restoration actions and human use, costs could be relatively modest because only a small number of cameras (e.g., ≤10) may be needed. Cost for effectiveness monitoring at the individual project scale, however, can be significantly higher (e.g., more cameras, longer duration of monitoring). Because of these costs, some participants expressed concern as to whether funds for camera monitoring should be dispersed among many projects or concentrated to a few projects with specific and focused objectives (e.g., testing the efficacy of a certain functional restoration technique).

Comparing Remote Cameras to Other Monitoring Techniques
When considering alternative methods or tools to monitor wildlife or human response to habitat restoration, none was considered more effective than remote cameras. Although the use of cameras has distinct limitations, they can collect more information, more consistently than other methods such as track or pellet surveys.

RECOMMENDATIONS

Based on workshop outcomes, we can make the following general recommendations:

1. Remote cameras are an effective tool for monitoring human use. Consequently, CHRF projects can continue to use remote cameras for this monitoring objectives. As an

additional side benefit, images collected from these cameras may contribute to communications about restoration projects.

2. HCTF should consider limiting the use of funding for remote cameras for monitoring wildlife responses in CHRF projects. Such limitations could include the requirement of using standardized restoration treatments and camera deployment across individual projects, or funding remote cameras in a few research-based projects that have explicit objectives and robust designs for monitoring wildlife responses to restoration. Careful consideration is also required to justify monitoring wildlife responses by remote camera in areas undergoing wolf management.

Although practitioners reported using remote cameras to monitor the condition of restoration actions, remote cameras are likely not necessary for this objective. In most projects, proponents will be returning to restored sites for other monitoring objectives (e.g., assessing vegetation responses) at which time the condition of restoration actions can be evaluated by field measurements and/or taking pictures while on site.

In the following sections, we expand on the above two general recommendations to give more specific guidance on the use of remote cameras as monitoring tools within CHRF projects.

Monitoring Human Use

For these objectives, cameras can be installed at points that previously allowed human access into the restored areas (e.g., installing cameras just behind road barricades). Locations and schedule of camera maintenance needs to consider potential effects from monitoring (e.g., site disturbance from accessing the cameras). Because the number of these locations will likely be limited within an individual project, the number of cameras required for these monitoring objectives will be significantly lower than the number of cameras required for wildlife monitoring (e.g., <10 compared to >60 for wildlife monitoring). For all projects, pre-treatment monitoring should be conducted, preferably for at least one year. In all instances, cameras should be installed with sufficient security devices (e.g., cables, locks, etc.) and camera locations should be hidden to the extent possible to minimize losses due to theft and vandalism.

Monitoring Wildlife

If wildlife monitoring remains a key objective for the CHRF program, we suggest that the following two frameworks be considered for guiding how remote cameras could be used for this purpose within CHRF projects. The first involves standardizing restoration treatment and monitoring designs across individual projects (the *Multi-site Framework*) to allow for the pooling of data across projects to gain more robust inferences on restoration effectiveness. The second framework involves partitioning CHRF projects into two streams (the *Separate Stream Framework*), one stream focused primarily on maximizing the amount of caribou habitat restored and the other focused primarily on applied research objectives that directly inform best practices and standards for caribou habitat restoration.

Multi-site Framework
Obtaining robust inferences on restoration effectiveness for individual projects is often difficult due to insufficient sample sizes for focal species with low rates of occurrence. Pooling data across projects can overcome this limitation, providing that protocols for camera and treatment deployments are provided to project proponents. Key criteria for such protocols include:

- Standardizing the brand of camera used and the way they are deployed (e.g., height off ground, orientation, camera angle) because these variables can confound inferences across projects (for example, see Apps and McNutt 2018, Urbanek et al. 2019). Guidance on camera spacing should also be provided to ensure that all deployed cameras are independent.
- Standardizing restoration treatments across projects if the objective is to evaluate the effectiveness of a given treatment. Currently, CHRF projects vary considerably in the type and intensity of treatments that are deployed. Although these variables can be controlled for statistically, it requires larger sample sizes than if treatments were standardized beforehand. Any variation from the standardized treatment arising from site conditions needs to be documented.
- Pre-treatment monitoring of at least one year for all projects.

An advantage to this framework is that the strength of inferences should increase over time as data from more projects accumulates. A potential disadvantage to this approach is that camera costs are incurred by many projects, which may impact HCTF program efficiency if the objective is to maximize the number of kilometers restored per dollar invested. Also, although standardization across projects is advantageous for pooling data, the type of monitoring standards/designs that are adopted may not be the most appropriate designs for addressing management objectives or research questions that may arise in the future. Another requirement of this framework is the need for a coordinated data repository and subsequent analyses of these pooled data to answer questions regarding restoration effectiveness, which can then inform best practices.

Separate Stream Framework
A second framework to consider is to separate CHRF projects into two separate streams: the Restoration Stream and the Applied Research Stream (Fig. 1). Projects in the Restoration Stream would primarily focus on maximizing the amount of caribou habitat restored using the best available practices and standards. Projects in this stream would focus solely on monitoring changes in human use and/or the response of vegetation (e.g., seedling survival and establishment surveys). Although monitoring of wildlife by remote cameras would not be supported in these projects, this does not preclude these projects from monitoring metrics that are directly linked to wildlife responses. For example, research suggests that if vegetation heights exceed 0.5 m on linear features, wolf selection of these features declines significantly (Dickie et al. 2017). Assessments of vegetation density using cover boards can also provide inferences on sightability down linear features. Because the CHRF program is focused on restoring caribou habitat to the greatest extent possible, we anticipate that the majority of CHRF projects would fall within the Restoration Stream.

Projects in the Applied Research Stream would be focused on specific objectives with outcomes that would directly inform best practices and standards for caribou habitat restoration (i.e., outcomes would contribute to learnings to ideally maximize restoration efficiency of future projects) and effectiveness of treatments. Such objectives could be suggested by the proponent or guided by HCTF in consultation with government biologists and other experts to address key knowledge gaps. Depending on the objective, wildlife monitoring by remote cameras may be required in these projects. For projects requiring cameras, proponents should have sufficient statistical expertise within their project team to justify their camera monitoring design. A power analysis is strongly suggested to support the number of cameras needed. We anticipate that only a small number of CHRF projects would fall within the Applied Research Stream.

An advantage to this framework is that funds for camera monitoring are focused on only a few projects that have predefined and specific objectives (versus dispersing funds across many projects without predefined objectives). This approach could be a more efficient use of funds both in terms of the number of kilometers restored per dollar invested in the Restoration Stream and information learned per monitoring dollar invested in the Applied Research Stream. Identifying additional partners should be encouraged to help address the longer duration and higher cost of Applied Research projects. A disadvantage to this framework is that the project requirements for the Applied Research Stream (e.g., sufficient statistical expertise) may limit the pool of proponents potentially applying for this type of funding.

CONCLUSION

Depending on a project's objectives, remote cameras can contribute to monitoring the effectiveness of caribou habitat restoration. If cameras are proposed as a tool for a given project, their application needs to be guided by/informed by the temporal and spatial needs to generate useful monitoring results. Assessing changes in human use can be achieved in a modest short term camera monitoring program. However, monitoring the effectiveness of a restoration treatment for caribou requires considerably larger commitment in cameras, time, and analysis. Project proposals should clearly describe project objectives that support their monitoring requirements.

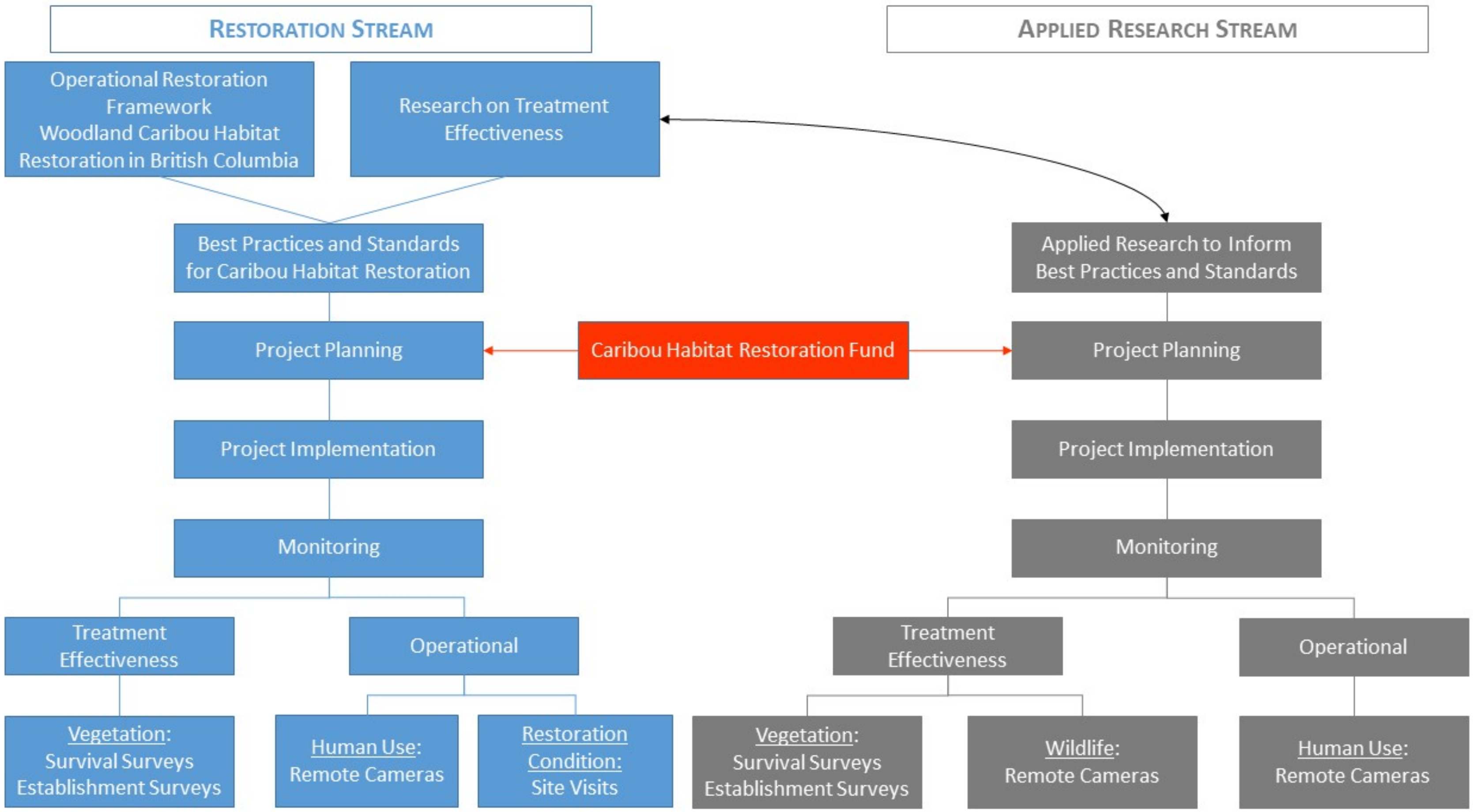

Figure 1: The "Separate Stream" framework, which partitions CHRF projects into two separate streams. Projects in the Restoration Stream are focused primarily on maximizing the amount of caribou habitat restored and proponents are required to only monitor the response of vegetation. Projects in the Applied Research Stream are primarily focused on addressing knowledge gaps to directly inform best practices and standards for caribou habitat restoration. Depending on their objectives, Applied Research projects may require remote cameras for monitoring wildlife responses.

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