NATURE-BASED SOLUTIONS: POLICY OPTIONS FOR CLIMATE AND BIODIVERSITY

FEBRUARY 2020

Smart Prosperity Institute

About Smart Prosperity Institute

Smart Prosperity Institute (formerly Sustainable Prosperity) is a national research network and policy think tank based at the University of Ottawa. We deliver world-class research and work with public and private partners – all to advance practical policies and market solutions for a stronger, cleaner economy.
institute.smartprosperity.ca

Written by Katherine Monahan, Ben Filewod, Stewart Elgie, John McNally and Shabnam Khalaj
February 2020

CONTENTS

This research was supported with funding from

METCALF FOUNDATION

mccall macbain FOUNDATION

Key Messages:

1 Canada's nature is a fundamental piece of the puzzle for fighting climate change.

2 However, policies that harness nature-based climate solutions (NCS), without considering biodiversity - and the other important ecosystem services that nature provides - risk undermining Canada's broader goals to protect nature.

3 Governments need to consider climate benefits and benefits to nature through a single policy lens.

4 Using a single policy lens can: (1) eliminate negative and inadvertent impacts on nature, (2) lead to better measurement and optimization of benefits for both climate and nature, and (3) lower costs and maximize value through efficient project selection.

5 Policy tools for advancing NCS include direct public funding, carbon offsets, regulations and pricing mechanisms. Optimizing outcomes using these tools requires a holistic approach to policy development.

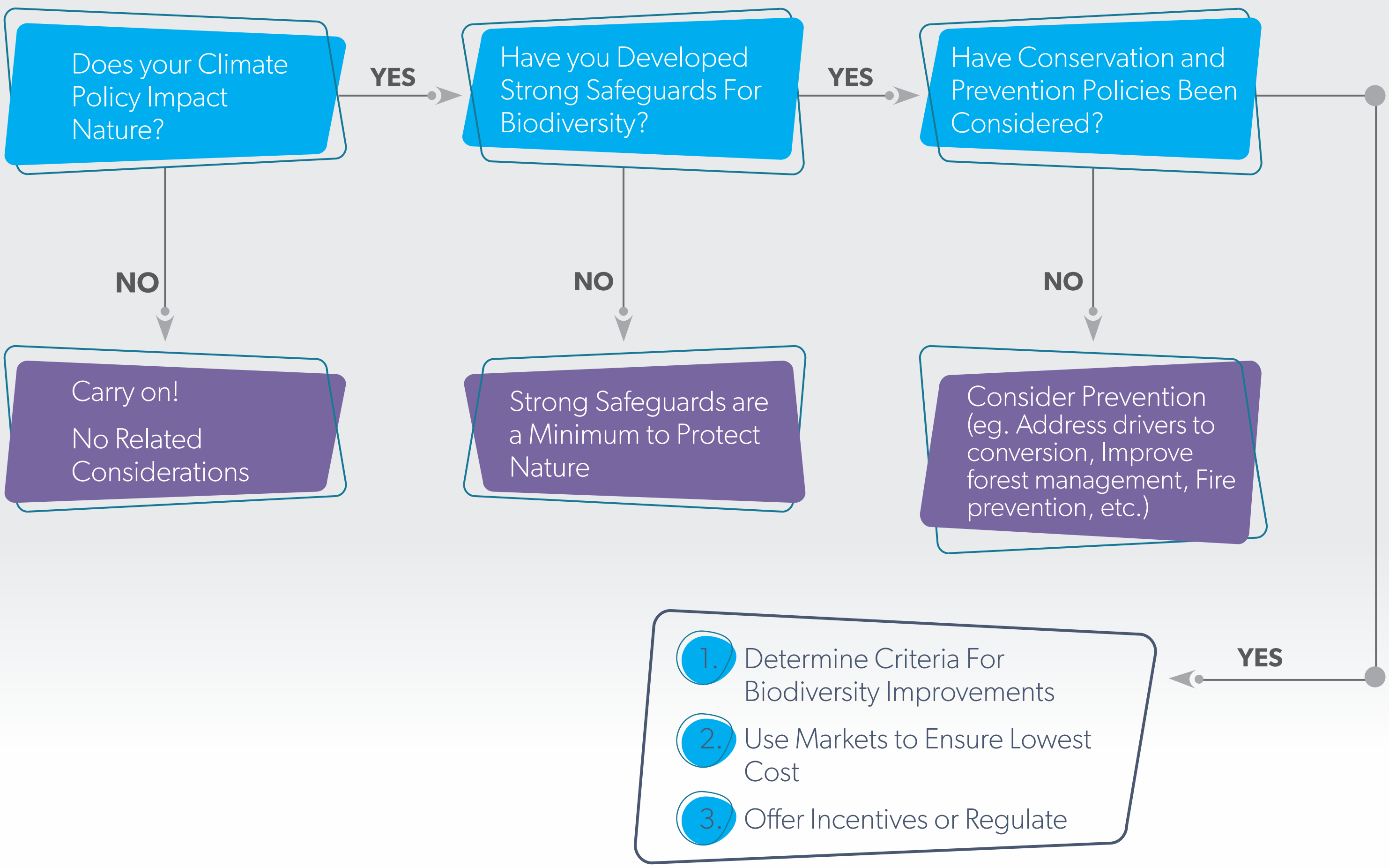
6 Direct public funding needs to ensure that actions result in real, additional, permanent and verifiable GHG mitigation outcomes, and also seek to avoid leakage. It should also require positive biodiversity outcomes through improvements in pre-selected criteria. Projects should be chosen based on best value for cost, which can be achieved through frameworks such as "reverse auctions".

7 Carbon offset frameworks can explicitly value carbon within forests and lands, thereby leveraging private sector investment. Biodiversity outcomes can be secured, at a minimum, by developing strong safeguards. Incentives or mandatory compliance obligations for offsets that offer biodiversity benefits are also an option. Offset stacking (the ability of one project to generate credits in more than one market) could, in theory, provide more appropriate compensation to projects that offer both climate and biodiversity benefits if and when these parallel markets are developed or strengthened.

8 Regulation or carbon pricing would require better tracking and reporting of land-based emissions to develop stronger accountability frameworks.

9 Developing evidence-based criteria for project selection could stem from economic valuation (though not recommended for programs that must evaluate many small projects), rule-based common unit comparisons, or continuous-improvement metrics that are compared based on their efficiency.

Policymaker's Guide to Integrating Biodiversity into Climate Policy



INTRODUCTION: THE BIGGEST BANG FOR THE BUCK

People often associate Canada with natural beauty and vast intact wilderness. Ten percent of the world's forests are located in Canada and the country holds nearly a quarter of the world's remaining wetlands[1].

This natural environment plays an important role in regulating the climate. All types of lands, including forests, wetlands, croplands, and grasslands, can produce large amounts of oxygen and store carbon, reducing atmospheric carbon dioxide. However, Canada's forests and lands can also be a source of greenhouse gas (GHG) emissions in the atmosphere when land and forests are burned, degraded or destroyed, for example through draining wetlands or deforestation.

Canadians are familiar with the concept of offsetting GHG emissions through programs that plant trees or protect forests and lands. These carbon offsets are available to businesses and individuals on a voluntary basis in Canada. The federal government will include carbon offsets as a compliance option for regulations governing large industrial emitters, while provinces continue to develop offsets programs of their own.

Governments can also improve net sequestration of GHGs in forests and lands through direct public funding. As part of its 2019 election platform, the Government of Canada pledged to plant two billion trees over ten years as part of a $3 billion fund to better manage, conserve and restore forests, grasslands, agricultural lands, wetlands and coastal areas[2]. The overall objective is to deliver an ambitious 30 million tonnes of annual net GHG sequestration in the year 2030 as part of Canada's efforts towards achieving its 2030 Paris climate commitment[3].

These actions, along with other policies and measures at the subnational level, point to the increasing focus on nature's role in climate change policy, often called "Nature-Based Climate Solutions."

And this is only the beginning. Nature-based climate solutions will be fundamental to meeting deeper decarbonization objectives. Without further policies to protect, conserve and sustainably manage forests and lands, it will not be possible for Canada to achieve its pledge to have net-zero emissions domestically by 2050.

But Canada's forests and lands also provide a wealth of other free services to Canadians, including clean water, fertile soil, and fresh air, underpinning our society and quality of life. Natural landscapes protect biodiversity and species-at-risk, boost human livelihoods and health, and sustain our resilience to climate change.

The term Nature-Based Solutions (NBS) refers to the ways that natural systems can be managed to help reach objectives like confronting climate change, reducing water pollution, and abating natural hazards. Nature-Based Climate Solutions (NCS) are a narrower class of NBS, specifically looking at the land sector's ability to mitigate and adapt to climate change.

The protection and restoration of biodiversity is a crucially important objective, one deeply intertwined with climate change. Any policy action on climate will also affect nature, and likewise, conservation and restorative action for nature will also affect climate.

A UN report in May 2019 stated that 1 million species worldwide are at risk of extinction[4], while other studies have discussed the alarming bird and pollinator declines here in North America (for example, bird populations have declined by 29% since 1970)[5]

As with climate change, Canada has commitments to improve biodiversity conservation under the United Nations Convention on Biological Diversity and under its Sustainable Development Goals[6]. In 2018, the federal government announced $1.3 billion to create new protected areas, and Canada recently committed to protecting 25 percent of Canada's land and 25 percent of our oceans by 2025 – with an ambition of 30 percent of each by 2030[7].

As Nature-Based Climate Solutions are developed, there is an opportunity for a multi-pronged approach. Policy interventions can aim to enhance benefits beyond carbon, including biodiversity and other benefits such as climate resilience (i.e., building adaptive capacity to the impacts of climate change) or local community development. Likewise, when biodiversity action is taken, there is an opportunity to better measure and optimize carbon benefits.

This won't be easy. Policymakers tend to work towards single objectives. Developing a holistic approach will require cross-cutting collaboration and multi-faceted analyses that consider a broader range of data. Likewise, a policy structure with multiple objectives can add costs and limit private-sector participation if overly complex.

The first step is to clearly define what we want to achieve and what our societal goals for Canada's lands really are. This paper assumes that Canada aims to maximize both climate and biodiversity values when developing land-based policies or funding models. Ensuring clarity on these multiple objectives will give us the best chance of reaching our goals while getting ***the biggest bang for the buck***.

OUTLINE

This paper explores policy options for climate change mitigation in the land sector (i.e., the part of Canada's land under economic management), including:

- Direct public funding (e.g., Natural Climate Solutions Fund)
- Carbon offsets
- Regulations and pricing mechanisms

The paper demonstrates how the land sector's unique characteristics require a more holistic approach to policy development under each of these models, one that considers both climate and biodiversity objectives simultaneously.

The main argument of this paper is that today's focus on using NCS to fight climate change risks undervaluing or ignoring the many other benefits the land sector can provide. In part, this risk stems from the fact that most ecosystem services are "free" public goods and therefore not counted or measured in the same ways as other assets with clear market prices. The other ancillary benefits that nature provides could be overlooked as policies are developed that bring natural carbon storage and sequestration under explicit management (e.g., carbon offsets).

There are at least three risks associated with ignoring biodiversity when developing NBS:

1. Poorly designed climate change policies can result in adverse impacts on biodiversity or other ecosystem services. For example, planting trees on natural grasslands or harvesting old growth forests to plant faster growing trees would destroy important ecosystems and their services
2. Projects may be ruled out because of high carbon costs even when they have high values in other areas. For example, wetland restoration can be costly from a climate change mitigation perspective on a per-tonne basis, but could result in biodiversity benefits and substantial cost savings associated with climate resilience
3. Pursuing multiple goals separately could be costlier and less efficient

This analysis is aimed towards policymakers and other stakeholders interested in Nature-Based Climate Solutions (NCS). The analysis describes potential policy tools that deliver GHG mitigation while also protecting or improving biodiversity indicators*.

Section 1 of this paper explores key examples of both private and public funding models for Nature-Based Climate Solutions, answering questions such as:

- What financing models exist to pay for NCSs? What regulatory options exist?
- How can these funds be used to maximize overall benefits for climate and biodiversity while optimizing costs?

Section 2 takes a deep dive into setting criteria for NBS project selection. The section explores economic valuation techniques and concludes with a recommendation on how to avoid ad hoc project selection.

* Although not discussed directly, it is possible that this analysis can be used to infer recommendations about other objectives such as Indigenous community economic development.

BOX 1

CANADA'S LAND SECTOR – GREENHOUSE GAS EMISSIONS AND SEQUESTRATION

Canada's National Greenhouse Gas Inventory Report* provides estimates for emissions and removals from Canada's land use, land-use change, and forestry sector (LULUCF). The LULUCF sector includes forests, cropland, grassland, wetlands, settlements and other land that are managed in Canada (i.e., under direct human influence), as well as emissions from harvested wood products.

Canada will count emissions and removals (sequestration) from the LULUCF sector towards its climate change commitments under the Paris Agreement of the United Nations Framework Convention on Climate Change. However, Canada will only count the emissions and removals that are caused by human activity (anthropogenic). Emissions and removals caused by natural disturbances, such as forest fires or pest infestations, are not counted as part of the commitment. Without this provision, the LULUCF sector would now be a large net source of GHG emissions.

Human activities that influence emissions and removals from the LULUCF sector include forest and cropland management practices, such as forest harvesting and crop tilling practices. Under this approach, forestland and cropland are counted as large GHG sinks each year in Canada, although these sinks have declined since 1990. Activities related to flooding lands and peat extraction in the wetland subsector, and conversion and control-burn activities in the grassland subsector, cause these subsectors to be sources of GHG emissions annually. Deforestation (or forest conversion)^ is currently responsible for 14 million tonnes of GHG emissions each year.

In total, the LULUCF sector provided a net 24 million tonnes of GHG removals in 2017 (i.e., a large net sink of GHG emissions). The ability of Canada's LULUCF sector to continue to contribute towards Canada's GHG mitigation objectives depends on expectations related to key activities, such as forest harvesting and the use of harvested wood products in building materials. Current Government projections show the LULUCF sector as a 28 million tonne sink in 2020 and a 21 million tonne sink in 2030**.

Projects or practices that strengthen management of lands could make the sector a larger net sink going forward. For example, policies and practices that increase stored carbon in forests (e.g., forest regeneration activities) and harvested wood products would contribute to the sequestration potential of the sector. Likewise, conservation activities could help decrease forest conversion rates. In contrast, practices such as increased peat extraction from wetlands or increased slash burning in forests would increase emissions, thereby weakening the sector's ability to act as a net sink.

Activities that relate to preventing or controlling natural disturbances such as forest fires and pest infestations will not contribute to Canada's achievement of its Paris Agreement target, but are nonetheless important for atmospheric levels of greenhouse gas emissions responsible for climate change.

* https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html
^ Not a formal reporting category since captured under forestland remaining forestland and other categories.
** https://unfccc.int/sites/default/files/resource/Canada%E2%80%99s%20Fourth%20Biennial%20Report%20on%20Climate%20Change%202019.pdf

SECTION 1: POLICY OPTIONS FOR NATURE-BASED CLIMATE SOLUTIONS: INTEGRATING BIODIVERSITY

Chapter 1: Public Funding

Nature-Based Solutions that result in climate, biodiversity and resiliency improvements represent positive benefits to society, justifying direct public subsidies and expenditure. NBS-type funds can be financed through general government revenue, revenue streams that are earmarked for environmental projects (e.g., sale of carbon-intensive assets; rents from fossil fuel or other resource extraction; etc.), or collected through climate regulations or carbon pricing initiatives.

Consistent with the Liberal platform commitments in the 2019 federal election, the Government of Canada announced its plan to create a $3 billion fund for Natural Climate Solutions with the intention of helping to deliver an ambitious 30 million tonnes of annual GHG emissions reduction towards the 2030 climate commitment under the Paris Agreement.[8]

Previously, the federal government established the Canada Nature Fund[9] through the $1.35 billion Nature Legacy Initiative to support the protection of biodiversity, ecosystems and species-at-risk. One of the key objectives of the Canada Nature Fund is to achieve Canada's goal to protect at least 17% of terrestrial areas and inland waters by 2020. The government's recent commitment to conserve 25% of Canada's land and 25% of its oceans by 2025 will require additional funding.[10]

Funding has already begun to roll out under the "Pathway to Canada Target 1 Challenge" and the "Nature Heritage Conservation Program" to help achieve the 17% goal. The funding is also being distributed through a Species-at-Risk stream that includes robust criteria for priority species, places and sectors.

These two funds have different principal goals and deserve separate treatment. However, promoting their synergies and integrating their objectives will ensure that efforts are complementary and mutually supportive.

- **The Natural Climate Solutions fund** will seek to deliver 30 megatonnes of GHG emissions net-sequestration annually, but should also aim to optimize the benefits that forests and lands provide beyond carbon sequestration, including biodiversity.

- **The Canada Nature Fund and subsequent funding streams** will aim to protect 25% of Canada's land and 25% of its oceans by 2025, but can also measure, report and optimize carbon sequestration benefits.

Federal funding through the Low-Carbon Economy Fund is also helping to implement projects that improve forest carbon sequestration. For example, the funding towards British Columbia's Forest Carbon Initiative aims to enhance forest regeneration in sites disturbed by wildfires and Mountain Pine Beetle infestation, as well as forest management improvements[11].

1.1 Establishing Guiding Principles for Project and Policy Selection

From a climate perspective, it makes sense to finance projects and policies with the lowest cost per tonne of GHGs abated, since the benefit of reducing one tonne of GHG emissions is generally considered uniform regardless of the jurisdiction or area where the mitigation action takes place (***see exception in box below***). Low-cost and efficient policy choices are key to a smooth transition to a low-carbon economy as well as maintaining public support for climate action.

BOX 2

TREE PLANTING: WHERE CLIMATE MITIGATION POLICY DOES NOT HAVE UNIFORM BENEFITS

Forest-based policies for climate mitigation in Canada, like other northern countries, are complicated by the "albedo effect" (i.e. how different types of land cover like cropland or forests reflect incoming solar radiation).

Tree planting, especially of dark green conifer trees, can lower the albedo relative to snow-covered areas and effectively create a warming effect relative to snow-covered or relatively light-colored land cover, especially in the North where snow exists for long periods of the year.

The albedo effect means the atmospheric benefit of planting trees will differ from location to location, in general decreasing from southern to northern Canada. The same pattern can occur on the biodiversity side of the equation. The number of species at any given site (species richness), including those at-risk, is not uniform across Canada. Rather, similarly to the land's capacity to absorb GHGs, species richness follows a general pattern of high richness in the south gradually decreasing towards the poles. Accounting for this regional variation will be important in the design of effective policies of climate mitigation that benefit biodiversity.

To ensure a benefit to the atmosphere, it is widely acknowledged and accepted that NCS projects and policies need to result in emission reductions that are:

- ⊗ **Real:** Conservative baselines are used to measure improvements
- ⊗ **Permanent:** Risks of intentional or accidental reversals of the carbon sequestration are mitigated or reduced
- ⊗ **Additional:** Situations where the project or activity would have happened in the absence of the policy lever are avoided
- ⊗ **Verifiable:** Emissions reductions are enforced, verified and protected
- ⊗ **Avoid Leakage:** Situations are minimized or eliminated where an improvement in mitigative activity in one geographical area leads to a worsening in another area (e.g. timber harvesting being displaced from one jurisdiction to another)

In traditional policy design or offset frameworks, safeguards for biodiversity are sometimes added to this list of principles for project selection. Safeguards can include high-level regulatory language that stipulates that projects or actions cannot cause harm to biodiversity. Or they can include specific requirements or lists of actions/projects that are now allowed (e.g., monoculture) (*see text box below for a discussion on safeguards*).

However, safeguards do little to advance biodiversity objectives, and so policies that incentivize or explicitly value biodiversity are needed. Without financial incentives, regulations or pricing mechanisms, farmers, land-owners, community developers and industry will fail to incorporate climate-related outcomes - or any broader societal benefits - into their management practices of Canada's forests and lands.

Modelling analyses of forest carbon point to significant mitigation potential from improvements in forest management.[12;13] The analyses show management practices such as optimizing the substitution of steel and concrete with harvested wood products (which continue to store carbon), and the increased use of waste wood for bioenergy could result in significant GHG mitigation in the medium to long-run.

However, the choice of NCS projects and policies may be quite different when considering biodiversity or other values that nature provides. Analyses that look at project or activity optimization from a purely climate perspective may result in project choices that do not advance biodiversity objectives. For example, the increased use of residues for bioenergy may be less desirable when biodiversity criteria are considered, as these practices can negatively impact the habitat value provided by dead wood in the forest or its soil health.

The challenge is that, from a biodiversity perspective, strict objectives are difficult to define and can be difficult to measure. Biodiversity benefits are multi-dimensional, scale- and geographically-dependent, and difficult to compare among sites. Determining biodiversity principles and criteria will be discussed in detail in Section 2. Generally, additional criteria could be layered onto climate criteria before looking at cost considerations. For example, additional criteria for land conservation projects may include:

- **Species-at-risk:** Is the project area (conservation area) located in one or more of the 11 priority places currently identified under the Pan-Canadian Approach to Transforming Species at Risk Conservation in Canada?[14] Has the location been identified as important to species-at-risk through community-nominated programs?[15]
- **Connectivity or conservation corridors:** How important is the area for the free movement of plants or animals across the landscape (e.g., migration stopovers for birds; seasonal movements for migratory animals like barren-ground caribou; etc.)? Does the area provide connectivity corridors among existing protected areas or spaces?
- **Compositional diversity:** Is there an abundance of plants or animals (measured by counting the number of plant or animal species present in a given area)? Is species endemism an issue?
- **Structural richness:** Is the structural heterogeneity of the forest or land promoting species diversity by providing a large number of different ecological niches?

These types of lists for biodiversity principles can be replicated from existing scientific sources. For example, the High Conservation Values (HCV) Resource Network identifies a list of six conservation values and discusses ways that these can be measured, tracked and compared[16].

BOX 3

CAN WELL-INTENTIONED TREE PLANTING INITIATIVES GO WRONG? THE CASE FOR STRONG "SAFEGUARDS"

In July 2019, the paper The Global Tree Restoration Potential* (Bastin et al. 2019) was published in the journal Science, with its principal message – that tree planting is a cheap and effective way to combat climate change – widely covered and endorsed by international media. The paper stated that the world could support an additional 0.9 billion hectares of forests, representing 1-1.5 trillion trees. These trees, it argued, could store more than 200 gigatonnes of carbon at maturity, representing up to 25% of the carbon currently in the atmosphere.

The paper was met with mixed reaction. On one hand, the IPCC's August 2019 special report on Climate Change and Land explained that the world will not be able to limit global temperature rise to 1.5 or 2°C without government climate action in the land sector including decreasing deforestation and forest regeneration, and the paper provided hope that a straightforward climate solution may be possible.**

On the other hand, the paper faced criticism from many experts.*** This criticism stemmed from specific errors, including overestimating the carbon uptake of trees, ignoring the warming effects of darkening planetary albedo over icy, more reflective terrain, and other methodological issues. There was also unease about the potential misinterpretation of the research: that humans could continue to emit greenhouse gas emissions and "*just plant trees to fix the problem*".

In addition, one of the biggest criticisms pertained to the minimal recognition the paper paid to the potential negative impacts from doing tree planting poorly, including on biodiversity, communities and local ecosystems. For example, the report's analyses assumed that grasslands could be forested, completely ignoring the immense biodiversity values of pasture and meadow ecosystems and how afforestation would destroy the life that depend on these habitats.

Another issue is forest fires. When forests are burned they release stored carbon into the atmosphere. Climate change is increasing the frequency and duration of forest fires worldwide, creating a need to carefully consider whether planting efforts will result in permanent or only temporary benefits for climate change.

Cautionary Tales

Well-intentioned climate-based policies in the terrestrial landscape can have adverse impacts on biodiversity. For example, planting non-native trees could radically alter local ecosystems, weaken biodiversity, or negatively impact water supplies through changes in the water table.

Examples from other jurisdictions highlight the risks of unintended consequences when tree planting policies go wrong. As a primary example, China's 1999 Green-for-Grain program (GFGP) resulted in the conversion of 28 million hectares of cropland and grassland into forest, and to date is known as the world's largest reforestation program. But forests replanted under the GFGP were dominated by monocultures or compositionally simple

A 2016 study in Nature Communications and led by Princeton University researchers examined the tree composition of reforested regions to understand the GFGP's implications on biodiversity (Hua et al., 2016).**** The study measured community- and species-level biodiversity metrics among bird and bee populations, concluding that GFGP's simple forests experienced losses of bird diversity and major decreases of pollinator diversity.

*https://science.sciencemag.org/content/365/6448/76
** https://www.ipcc.ch/srccl/
*** https://www.sciencemag.org/news/2019/10/catchy-findings-have-propelled-young-ecologist-fame-and-enraged-his-critics
****https://www.nature.com/articles/ncomms12717

The study noted that the GFGP had failed to restore biodiversity to levels approximating native forests. To make matters worse, planting of non-native tree species in arid areas decreased local groundwater levels and lowered the overall water table in drought-vulnerable regions, undermining resilience to climate change.

This type of example highlights the need for strong biodiversity safeguards in climate-related projects (e.g., a requirement to re-plant with native species). These safeguards should be inherent to any government policy that directly or indirectly impacts the land sector. For example, the new federal Clean Fuel Standard in Canada may have indirect impacts on the land sector. As the demand for biofuel increases, biodiversity safeguards could ensure forests are not converted to cropland for biofuel purposes regardless of overall life-cycle GHG emissions.

1.2 Reverse Auctions – A Market-Based Solution to Minimize Costs

Once project criteria and principles have been determined, funding models are needed that seek to optimize benefits while minimizing costs. This section explores "reverse auction" models as one such example.

There are many lessons that can be drawn from financing models for conservation (i.e., where carbon sequestration is not the primary objective). The overarching frameworks usually consist of bidding processes that can be interpreted in economics as "reverse auctions" where multiple landowners or rights-holders submit competitive bids to provide environmental services, which are then compared against each other.

A reverse auction is a type of auction where the role of the seller and buyer is reversed. In this case, the government would be the only buyer (or funder) where multiple project proponents would compete to get funding for their projects. The government would put out a request for an NCS project (e.g., land conservation; replanting activities; etc.) and project proponents would describe potential projects, how they adhere to selection criteria and principles, and related costs.

BOX 4

WHO ARE THE PROJECT PROPONENTS?

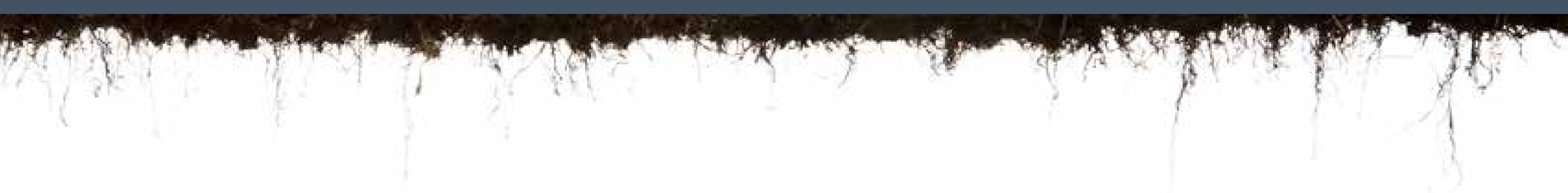
Reverse auction models are most readily applicable to private land owners, including private forests and farming land-owners on agricultural cropland.

However, in Canada, 94% of forest land is publicly owned (90% provincially and 6% federally or Indigenous land). In the case of public forests or lands, reverse auction models could be used by the federal government to incentivize conservation or restoration action from provinces, municipalities or Indigenous communities. These local governments could be looking for additional funding to help regenerate areas that have been depleted or degraded (e.g., such as through forest fires), or to pay for ongoing monitoring costs for conservation areas.

Likewise, project proponents could be looking for funding to purchase development rights or timber quotas from provincial governments. In theory, legal instruments such as conservation easements or natural resource dispositions could then be used by provincial governments to create parks or protected areas in these locations.

Also note that private projects on public lands may be possible. The province of British Columbia developed an innovative framework "Atmospheric Benefit Sharing Agreements" to deal with the issue of creating property rights for carbon sequestration benefits on provincial crown land*. Rights to use the land for carbon sequestration projects are authorized through either tenures or licenses, and a set of terms is either included in the agreement or a supplementary agreement is drafted.

* https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-first-nations/first-nations-negotiations/atmospheric-benefit-sharing-agreements



In many ways, reverse auctions are similar to the model used by the federal government under the Challenge component of the Canada Nature Fund. However, important differences exist, including ways to ensure that costs are minimized (since project proponents bid against each other), and that consistent selection criteria are optimized (challenge models often lack explicit environmental benefits indexes). Challenge funds may also include requirements that are not relevant to reverse auctions such as matching fund requirements or geographical representation.

Within Payments for Ecosystem Services models, land conservation tenders (reverse auctions) are used where funding is allocated to private landholders who can deliver land management practices most cost effectively. After ranking the bids based on cost and the selection principles (criteria), the funds are allocated to projects that bring the best value for money.

The reverse auction mechanism, if well designed, eliminates the informational rent that project proponents have over government on the actual cost of offering the environmental services. A growing literature on conservation auctions suggests that depending on the context and design of the program, they outperform fix-payment schemes for conservation, with cost savings between 16 to 315 percent.[17]

1.2.1 Challenges and Design Options for Reverse Auctions

One of the essential factors in the success of reverse auctions is the participation rate. With a low participation rate, the odds of funding a project with a high bid-benefit ratio increase. Different factors can affect the participation rate, such as high perceived transaction costs, landholder's belief about the probability of bid acceptance, and complexity of the auction structure.

The second challenge involves strategic bidding. If the perceived probability of the bid acceptance is high, the landholder has an incentive to inflate the bid.[18]

Finally, reverse auctions must ensure that project criteria and principles are comparable. This challenge could be overcome by developing class categories for each principle considered. For example, Alberta's Wetland Policy offsetting scheme provided an evaluation rubric for four dimensions of wetland quality.[19] By scoring wetlands on each dimension of quality, expert assessors assigned each wetland to an overall quality class. Wetlands within the same class are fungible, while wetlands from different classes must be exchanged in fixed ratios – for example 1 hectare of wetland in the top-quality class can be replaced by 1 hectare of wetland in this same class, or by 8 hectares of wetlands in the lowest quality class – in this case via the provision of an evaluation rubric to guide expert assessment. This type of model could be used to develop a framework to compare project bids for reverse auctions for climate and biodiversity.

For a discussion on reverse auction models in practice, see Annex 1.

Chapter 2 – Achieving Multiple Objectives through Carbon Offsets

A carbon offset is a GHG mitigation outcome that can be used to compensate for emissions created elsewhere. There are several carbon offset protocols in Canada related to NBS (i.e., terms of reference for a particular project type), including various offset protocols on the voluntary market and existing/forthcoming offset protocols on provincial compliance markets. ***See Annex 2 for a complete list of NBS related protocols on compliance markets***. The federal government is currently developing an offset framework that will recognize robust provincial offsets as well as potentially develop offset protocols of its own.[20]

The remainder of this chapter describes ways that governments can create demand for carbon offsets with ancillary or multiple benefits, with a focus on biodiversity.

Achieving multiple objectives through carbon offsets is not a new concept but remains a contentious one. There is very little real-world experience on how carbon offsets can achieve multiple objectives in compliance markets. Carbon offsets are inherently designed to realize the cheapest GHG mitigation options (i.e., those with the lowest marginal abatement costs). Additional criteria generally add to costs.

This chapter discusses two options to integrate biodiversity into carbon offset frameworks:

1. Integrating biodiversity directly into carbon offset protocols
2. Biodiversity and carbon offset credit stacking

2.1 Integrating Biodiversity into Carbon Offset Protocols

Additional accreditation for biodiversity improvements has been successful in the voluntary market. Leading voluntary standards (e.g., VCS, Gold) do not address co-benefits directly, but instead utilize add-on co-benefit certification schemes. The largest of these - Climate, Community and Biodiversity Standards (CCB) - employs a net positive principle across multiple domains. Rather than compare classes of co-benefits, project proponents must demonstrate net gains in each class over the project lifecycle. In addition, CCB requires identification and demonstration of no negative impact on high conservation values.

A competing standard - Social Carbon (SC) - employs a continual improvement principle. To maintain certification, project proponents must show that outcomes are improving at each verification period in all classes of co-benefits. Whereas CCB uses a traditional criteria and indicators approach, SC scores outcomes using a simple rubric. Both approaches rely considerably on the subjective evaluation of the assessor.

However, these "multi-benefit" credits may face higher costs (including transaction costs), making it challenging to compete with other carbon offsets targeting purely GHG mitigation outcomes. For example, a forest carbon offset that is required to achieve carbon, biodiversity, ecosystem and community development benefits, could be far costlier than offset types that are aiming to only maximize climate benefits.

On the voluntary carbon market, buyers are often willing to pay for this premium quality as part of a more robust narrative on what they are doing for the environment. These buyers are motivated by ideological, social license or public image concerns, and may therefore pay a premium for offsets that include co-benefits. Internationally, the volume of carbon credits is oversupplied on the voluntary market, but demand remains for the highest quality units.[21]

However, on compliance markets, regulated firms will typically seek out the lowest cost legal compliance instrument.

The following section describes options for integrating biodiversity objectives into carbon offsets on compliance markets.

Option A - Regulatory Compliance

Under this approach, regulated firms would need to meet a particular percentage (x%) of their compliance obligation (e.g., emissions above benchmark) through the purchase of "multi-benefit credits" (e.g., credits that include a positive biodiversity outcome). The remaining obligation could then be fulfilled through existing compliance options, including other types of offsets.

This option essentially creates a tiered approach to using offsets for compliance. For example, a firm wishing to use offsets for 100 tonnes of its offset-eligible compliance obligation would

BOX 5

CARBON OFFSETS AS A FUNDING TOOL FOR NBS

Traditionally, carbon offsets have been used by firms or individuals that are not able or willing to reduce their own activity-related emissions (e.g., corporate footprint, air travel, etc.) and so choose offsets as a cheaper or more accessible option that reduces the same amount of GHG emissions elsewhere.

When considering carbon offsets from this viewpoint, there is often concern that the tool results in no net-benefit for the environment. That is to say that the purchaser of offsets is granted a "license to pollute" and simply purchases offsets instead of decarbonizing or reducing GHG-intensive activities. At best, this would leave the world no worse off. At worse, this can exacerbate climate change by: crediting a faulty project which does not reduce emissions; adding complex transaction costs to an overburdened pricing system; and dampening the effective carbon price, thereby lowering incentives for abatement and innovation.

However, there are a few strong arguments for why carbon offsets are important, and when considered together make a strong case for their use as a policy tool for NBS

- The private sector pays for carbon offsets. Carbon offsets allow private sector capital to flow directly to priority areas, including Nature-Based Solutions. The scale of investment required to address climate change is above the possibilities of the public purse, and private sector financing will be needed.
- Robust carbon offset frameworks provide strong measuring, reporting and verification requirements to ensure that projects result in genuine benefits to the atmosphere.
- Carbon offsets can lower compliance costs for regulated firms. Finding cost effective mitigation options will help lower the overall costs of transitioning to a low-carbon economy and make it possible to ratchet-up our ambition.
- Carbon offsets can draw the land sector into carbon pricing.

In Canada, the final design of the federal government's Output Based Pricing System (OBPS) was released on June 28, 2019 and outlines how carbon offsets can be used for regulatory compliance. Large industrial emitters that emit over the sector benchmark must exercise one of three options: (1) purchase offset credits, (2) buy surplus credits from other regulated firms, or (3) pay a direct charge to government.*

This third compliance option ensures that profit-maximizing firms will only reduce emissions until the marginal cost of doing so is equal to the fuel charge (benchmark carbon price).

From an environmental perspective, the principal benefit of including carbon offsets under the OBPS is that when firms cannot abate emissions internally, private sector revenue flows directly to offset projects that can have a material impact on Canada's GHG emissions. In the absence of the availability of offsets, this compliance revenue would flow to the government.

Instead, this private capital could fund offset projects in areas and sectors that are not covered by the carbon fuel charge or subject to OBPS regulations. The market (i.e., regulated firms) will choose to buy the lowest price carbon offsets, ensuring efficient projects are chosen.

* For 2019 and 2020, there is no maximum for the use of offsets and surplus credits. For post 2020, facilities will only be able to cover 75% of their compliance obligation through offsets and surplus credits.

purchase y% of these offsets at the cheapest market price. However, the other x% (where x = 100 – y) would need to come from the premium "multi-objective" offset market.

The advantage of this approach is that no direct public funding would be needed. The drawback is that it adds another level of rules or complexity to regulations and likely raises transaction and compliance costs.

Option B - Top Up Funding for Biodiversity Benefits (Hybrid: public-private approach)

NBS offsets have the opportunity to achieve the co-benefits society desires, and top-up funding is a way to unlock these benefits. Under this approach, a government could pay a price top-up to carbon offset projects (in addition to the offset price received on the compliance market) that deliver both climate and significant biodiversity improvements, and thereby reflect the extra costs and benefits for such projects.

That is to say, that "multi-benefit" offset projects would continue to register their credits on the compliance market. However, the government would provide qualifying project proponents with an additional top-up above and beyond the price they receive on the private market, compensating these projects for the value of the delivered biodiversity benefits.

This additional economic incentive would help landowners, farmers and communities protect and restore biodiversity in wetlands, grasslands, forests and agriculture soil, while being assured that their investments will be financially sustainable – thereby attracting a broader suite of projects.

In many respects, this is a payment-for-ecosystem-services approach, with private firms (i.e., regulated firms buying offsets) paying most of the cost, with the additional benefit of also leveraging greater land-based sequestration projects.

BOX 6

TOP-UP PRICE SETTING

Section 2 provides a review of methods to compare a project's benefits, some of which could be used to set top-up prices. For example, economic tools (monetary valuation) could be used to establish a price ceiling for top-ups. Alternatively, analysis of the prices paid for premium offsets in the voluntary carbon markets could be used to determine top-up prices.

However, a program that attempts to set top-up prices using estimates of the "true" value of co-benefits may face an uphill struggle. Although not as efficient, a reasonable per-project maximum or uniform price might be desirable to ensure a diverse portfolio of projects is funded while reducing complexity.

In all cases, adding a top-up mechanism to carbon offsets carries the risk of increasing transaction costs for running and operating the offset program. Timing and administrative requirements should be carefully considered.

2.2 Biodiversity, Conservation and Carbon Offset Credit Stacking

Since NBS projects provide multiple benefits, project participants that receive credits for carbon alone are often only being compensated for part of the overall NBS value they have helped create or conserve.

One solution is to allow for a single action with multiple benefits to generate two or more credits in different offset markets. This is called "credit stacking". Markets that permit credit stacking allow for one action to generate multiple credits for private landowners across different markets that value those services.[22]

Although credit stacking offers potential for landowners to earn higher returns and could potentially incent additional conservation action, parallel markets for conservation or biodiversity would need to be further developed for this to work in practice in Canada.

Markets for "conservation offsets" do exist federally as well as in five Canadian provinces: British Columbia, Alberta, Nova Scotia, New Brunswick and Ontario.[23] The majority of conservation offset markets in Canada operate under a "no net loss" principle for wetlands or fish habitat, which requires any action that results in a reduction of wetland or fish habitat to replace the loss with the creation of an area with an equivalent or greater natural value.[24]

BOX 7

THE POTENTIAL FOR CREDIT STACKING – POTENTIAL SUCCESS STORY?

The Lake Taupō nitrogen trading program in New Zealand was established in 2009[25]. The trading program targeted reductions in fertilizer use by farmers while allowing for nitrogen allowances to be stacked with carbon credits from the national cap-and-trade market.

Program participants noted that one impact of the policy was that it supported forest planting on marginal or less productive agricultural lands without impacting overall agricultural productivity. This finding indicates that the ability to stack credits potentially led to more productive use of existing agricultural land than would have happened in the absence of credit stacking, thereby enabling efficiency gains at the farm-level while supporting action under both markets.

Barriers to Credit Stacking in Canada

Despite its theoretical potential, credit stacking faces a number of barriers to being applied in practice. Apart from a few isolated examples, the technique has rarely been used by policymakers. There are both theoretical and practical reasons for this caution.

Theoretical barriers include the perception that credit stacking could compensate actions that are not additional to what would have happened in the absence of the program (additionality concerns). Likewise, there is a perceived risk that ecosystem services could be overvalued. The value of an individual ecosystem service, such as water filtration in a forested area, can be difficult to determine independently from all other services. Payments that attempt to properly compensate each individual service may end up over-compensating landowners by providing more compensation for two actions than they are worth independently. This scenario leads to funds that could have been spent on other sites or ecosystem services being used inefficiently.

Another challenge with credit stacking is related to interactions between regulators. In regions where overlapping markets are overseen by different regulators, such as provincial and federal governments, there is a risk that different markets value costs and benefits non-symmetrically. This situation means credit stacking could result in markets valuing the same services differently and thereby threaten the integrity of transactions. One approach is to assess credit stacking requests between markets overseen by different regulators on a project-by-project basis to ensure individual actions are valued equivalently.

As already noted, for credit stacking to work, biodiversity or conservation offset markets would need to be further developed. Recent assessment of environmental credit markets in Canada found that the relatively small number of current markets does not have the scale or scope to support meaningful credit trading.[26]

The growth of conservation offset markets requires policies that drive demand for investment into conservation in the first place. Demand creation can take the form of a regulation mandating biodiversity impacts be equivalently offset, or economic instruments imposing a monetary cost per unit of habitat destruction (such as payment in lieu of fee).[27]

The new Impact Assessment Act[28] for major projects requires project proponents to describe how they will mitigate any project-related loss or damage to lands and biodiversity. This could include a requirement to re-establish or offset damaged lands, often with a goal of pursuing "no net loss" to biodiversity or habitat. Markets for habitat and conservation offsets could become more robust as the act matures.

Credit stacking offers opportunities to support conservation action by ensuring landowners are compensated for the value of their investments. Yet enabling stacking with regulated carbon offset markets is not enough. For stacking to reach its full potential, it must overcome the existing theoretical and practical barriers to implementation. These include developing environmental markets that value ecosystem services for the generation of credits that can be stacked, the installation of demand drivers for investment into conservation offsets, and the alignment of valuation and accounting standards to maintain the integrity of credit stacking schemes.

BOX 8

STACKING CONSERVATION CREDITS WITH CANADA'S FEDERAL GHG OFFSET SYSTEM

Canada's federal GHG offset system could supply stackable environmental credits. A recent federal discussion paper noted that the government will consider opportunities to permit credit stacking with conservation schemes as they emerge.* If the federal government does permit credit stacking between two offset systems through a recognized framework (rather than simply on a project-by-project basis) the following two principles should be considered:

- Agencies and developers should use the same accounting methodologies for debits and credits.** If it is not feasible to have identical systems, accounting systems should, at a minimum, be reconcilable to ensure credit issuance maintains integrity across all markets, particularly to avoid double-issuance.
- Additionality risk should be accounted for through the application of an appropriate discount factor.*** This discount factor could be applied to all credits in a stack, or could solely apply to any secondary credits that are generated by a project that has already received credits in one environmental market.

* Government of Canada. (2019). Carbon Pollution Pricing: Options for a Federal GHG Offset System. Retrieved from https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/pricing-pollution/Options-GHG-Offset-System.pdf
** Robertson, M., BenDor, T. K., Lave, R., Riggsbee, A., Ruhl, J. B., & Doyle, M. (2014). Stacking ecosystem services. Frontiers in Ecology and the Environment, 12(3), 186–193. https://doi.org/10.1890/110292
*** Fox, J., Gardner, R. C., & Maki, T. (2011). Stacking Opportunities and Risks in Environmental Credit Markets. Retrieved from www.epri.com

Chapter 3. Carbon Pricing & Regulations

Increasingly, Canadian policymakers recognize the value of Nature-Based Solutions in sequestering GHG emissions responsible for climate change. But the land sector can also be a large source of emissions, such as when stored carbon is released when forest fires occur; or when stored carbon, methane and nitrous oxide are released when land and soil are disturbed or wetlands are drained.

When these changes are caused by humans (i.e. anthropogenic), the resulting emissions are counted as part of Canada's total GHG burden. But who exactly is responsible for these anthropogenic emissions and how can they be regulated?

BOX 9

NATURAL CLIMATE SOLUTIONS: REDUCING EMISSIONS OR INCREASING SEQUESTRATION?

The land sector is unique from other sectors because of its ability to act as both a source and a sink of GHG emissions.

Avoided Emissions: Projects that conserve and protect an area that would otherwise have been destroyed or disturbed, avoid emissions that would have occurred in the absence of the project or policy. These types of projects have the advantage of resulting in near term GHG benefits (i.e., since the emissions that would have taken place through land destruction are prevented). However, one argument against this type of project are unintended consequences. For instance, a forest fire can sweep through an area that is conserved for the purposes of GHG mitigation, thereby causing the stored carbon to be released -- a release of emissions that may be higher than what would have happened if the forest was not conserved. With forest fires increasing due to climate change, this "non-permanence" concern is driving new actions and research into management practices that prevent fire or reduce fire risk.

Enhancing Carbon Sequestration: Projects such as afforestation (planting trees where they were not found previously) or the increased use of harvested-wood products in building materials (where wood continues to hold stored carbon), can provide net-sink benefits (once the emissions and removals associated with replanting activities or forest harvest are accounted for). Note that afforestation initiatives are also subject to the "permanence" concerns described above.

Canada abides by the "polluter pays" principle under the federal Canadian Environmental Protection Act.[29] This principle suggests that those causing the GHG emissions are responsible for the costs relating to the environmental damage they cause.

Carbon pricing ensures that emitting greenhouse gas emissions comes with a cost and therefore provides a financial reason to limit or mitigate GHG emissions. While most GHG emissions are now subject to carbon pricing in Canada there are currently no pricing policies or explicit accountability frameworks for the anthropogenic GHG emissions coming from the land sector.

The final strategic assessment of climate change within the federal Impact Assessment System could prove to be an example of an accountability framework that considers both land sector-related GHG emissions as well as disturbances to ecosystem services and biodiversity together. In addition to describing mitigation measures for lost or damaged habitat and ecosystem indicators, project proponents will need to quantify direct and indirect GHG emissions arising from the project, including emissions from land clearing (e.g., land use change such as deforestation, biomass decay, etc.).[30]

Meanwhile, one of the challenges facing regulatory and pricing measures being applied to the land sector is measurement and estimation. Although GHG emissions from the land use, land-use change, and forestry (LULUCF) sector are reported in the National Inventory Report (see Box 1), some changes to land-use and activity related emissions are not captured. National reporting has not begun in some areas (e.g., emissions and removals from seagrass meadows in coastal ecosystems). As a concrete example of the issue, a recent report demonstrates that when forested area is cut down to build a new road, the associated GHG emissions could be ignored or underreported by provinces if the road is not permanent (e.g., service or forestry road)[31]. Likewise, emissions associated with tress that are logged to create a permanent road will be ignored if the road is less that 20 meters wide.

When GHG emissions are tracked and recorded, accountability frameworks can be established. Like with GHG emissions arising from other sectors, policy tools include regulations, subsidies, carbon pricing and information-based policies.

Section 1 - Key Takeaways

- There is significant opportunity to decrease GHG emissions and increase GHG sequestration in Canada's forests and lands.

- However, the land sector is unique from other sectors of the economy because any climate-related policy action will also have implications for biodiversity and other ecosystem services. Policy action must also consider impacts on local resource industries and Indigenous and other community development.

- Strong safeguards can ensure that climate-oriented projects and policies do not harm biodiversity, but these safeguards are not enough to incentivize biodiversity ***improvements***.

- There are several policy tools that Canada can use to strengthen climate mitigation in the land sector, including funding, regulatory and market-based instruments.

- Optimizing both climate and biodiversity benefits using each of these tools requires a holistic approach to policy development, as follows:

    - NCS funds need to ensure that actions result in real, additional, permanent and verifiable GHG mitigation outcomes, and seek to avoid leakage. They must also require positive biodiversity outcomes through robust criteria selection.
    - Once criteria have been selected, projects should be chosen based on best value for cost. Ensuring lowest cost can be achieved through "reverse auction" frameworks, where project proponents are responsible for demonstrating overall project value (based on criteria) and bid against each other. Several technical challenges can be addressed through program design.
    - Carbon offsets have the ability to explicitly value carbon within forests and lands, thereby leveraging private sector investment into NBS. Carbon offsets can also ensure robust biodiversity outcomes by, at a minimum, developing strong safeguards. To incentivize positive outcomes, governments could require a certain percentage of compliance units to come from offsets with additional accreditation for biodiversity. Alternatively, governments could offer project proponents a price top-up above and beyond what they receive on the market when biodiversity improvements are demonstrated.
    - Offset stacking (the ability of one project to generate credits in more than one market) could, in theory, provide more appropriate compensation to projects that offer both climate and biodiversity benefits. However, this cannot happen in practice unless markets and demand for biodiversity credits are further developed.
    - Canada's forests and lands can also be large sources of anthropogenic emissions when lands are degraded, disturbed or destroyed by human action. Better tracking and reporting of land-based emissions can facilitate the development of accountability frameworks and pave the way for regulation or carbon pricing.

- The advantages of looking at both climate and biodiversity through one lens include:

    - Exclusively climate-focused policies can result in adverse impacts on biodiversity. Likewise, exclusively biodiversity-focused projects can fail to measure, track and optimize carbon benefits.
    - Project selection that is based solely on climate mitigation potential could miss the opportunity to harness biodiversity-rich outcomes.
    - Seeking to optimize biodiversity and climate benefits in project selection will generally be more cost efficient than when these goals are pursued independently.

- Clear indicators of biodiversity improvements must be developed. Evidence-based decision making and clear and consistent sets of criteria are needed to avoid subjective or ad-hoc decision making (see section 2).

The Multiple Benefits of Canada's Nature

- Forestry activities and hunting
- Small ponds for river floods
- Wetlands for wastewater treatment
- Clean Water
- Wetland regeneration for flood control
- Green roofs and greenspaces for heat control in urban environments
- Protection of species at risk
- Clean Air
- Local and Indigenous economic development forestry activities and hunting
- Recreational values
- Mental health values
- Biodiversity

SECTION 2: EVIDENCE-BASED CRITERIA FOR PROJECT SELECTION

Nature-Based Solutions rely on interventions in natural systems that are heterogenous, complex and dynamic. To deliver carbon or biodiversity benefits, policymakers must draw on scientific knowledge to measure and predict outcomes. To achieve economic efficiency, methods are needed to compare between projects and select those that deliver the greatest gains per unit of inputs. Making comparisons is necessary to bring non-carbon land use impacts into a compliance regime, to add co-benefits to existing offset systems, or to direct government funding to mitigation projects that also deliver biodiversity outcomes.

Unlike "mitigation only" projects, comparing nature-based solutions is complicated by a heterogenous set of benefits provided by different projects. The fundamental challenge is the lack of a common unit of measurement for comparison. Unlike the use of carbon dioxide equivalence (CO_2^e) to compare mitigation outcomes, there is no single metric to compare the biodiversity, ecosystem services or social benefits associated with nature-based solutions.

BOX 10

THE TECHNICAL PROBLEM OF COMPARING BIODIVERSITY OUTCOMES

Imagine two projects that intervene in natural systems to achieve 100 Mt of mitigation. One project occurs in a forest, while the other occurs in a wetland. Modelling ecosystem processes in both systems results in a tally of flows of gases to and from the atmosphere, which can be summed in CO_2e on the basis of well-known physical relationships (such as global warming potentials of different GHGs).

Both projects also impact biodiversity, and there is no 'best' solution to compare these impacts. The abundance of turtles and the diversity of forest songbirds, for example, cannot easily be converted into a common unit for comparison. Impacts may also depend on a larger context – how can preserving habitat for a rare fish species and protecting a forest corridor between two reserves be compared?

There are no easy answers, but there are tested (and promising) solutions. Underling all methods is the recognition that comparison criteria for ranking Nature-Based Solutions depend on societal preferences and goal-setting. Policy design must promote outcomes that match the preferences of all stakeholders, and find methods that are as objective as possible.

1. Comparing Projects

In existing carbon offsets frameworks, positive outcomes associated with Nature-Based Solutions are often deemed "co-benefits". Meanwhile, a single project may have many "classes" of co-benefits - for example, biodiversity vs. other ecosystem services - and a single class may have many "dimensions" of benefits - for example, genetic diversity vs. species diversity. Each class of co-benefit, and the various dimensions of outcomes within a class, may be fundamentally incomparable. The following discussion focuses on a single class: biodiversity.

For the purposes of comparison, it is possible to collapse dimensions of a class of co-benefits using class-specific tools or by employing economic methods for monetary valuation. The latter can also be applied across co-benefit classes.

In either case, the methods rely on choices or preferences about the relative importance of different dimensions or different classes. These choices may be criticized (Box 11[32]). An alternative approach is to compare co-benefits across multiple dimensions simultaneously. But in this case only certain types of comparison can be made.

2. Collapsing Dimensions: How Can we Compare Co-Benefits in a Common Unit?

Comparisons between co-benefit classes and across dimensions within a particular class can be made 'in common terms' when scoring in a common unit is possible. The typical approach is to value outcomes in monetary terms. Aggregating over dimensions within a class can also be used to produce a common unit for comparison, typically a unitless index.

The options for monetary valuation
Monetary valuations measure human preferences. Whose preferences are measured depends on the sample group and the valuation method. Of course, most of the benefits of NBS are not transacted in markets. Instead, preferences must be elicited or inferred. The field of environmental economics offers a wide array of methods, each with its own theoretical and practical advantages and disadvantages. For the purposes of exposition, methodologies may be grouped as direct or indirect[33]:

- ***Direct valuation*** methods try to measure preferences by asking about values or conducting experiments. The typical approach in environmental economics is to conduct surveys in which questions or choices between options are used to elicit values for non-market goods and services. These “stated preference” approaches rely on contingent valuation methods or choice experiments.[34] Despite their widespread use, such methods are theoretically controversial[35] and expensive,[36] and results are context specific. Recent advances have also challenged the validity of “workhorse” approaches. For example, insights from behavioral economics suggest that Willingness-To-Accept (WTA) is more appropriate than Willingness-To-Pay (WTP) when changes to natural systems are viewed by recipients as making up for an earlier loss or degradation of a natural system. Significant divergence between WTA and WTP results[37] have called into question the longstanding tradition of using WTP to value heterogenous outcomes in a common (monetary) unit.

- ***Indirect valuation*** methods try to infer preferences from observations of real markets. A wide array of methods are available, ranging from techniques such as “hedonic valuation” to “dose-response”, to least-cost alternative methods and shadow pricing. In general, such methods require a defined relationship* between the non-market entity being valued and real markets where prices can be observed. For example, an equivalence relationship allows the application of least cost-techniques, as were implicit in the famous case of New York City’s watershed protection program.[38] Where such relationships exist, data requirements, validity of resulting estimates, and expense vary substantially per method and results are characterized by a high degree of context specificity.

The strengths of monetary valuation are its flexibility and generality: all outcomes of Nature-Based Solutions can in theory be valued in monetary terms to provide a clear, actionable metric that captures human preferences. Its weakness is complexity: different methods (and methodological choices) can produce very different results; applied applications frequently suffer from fundamental errors; and rigorous studies require highly trained (and expensive) personnel. Transferring results to novel context, which is frequently required by policymakers, may be difficult or impossible. It is noteworthy that in none of the case studies described in this report was the choice made to employ monetary valuation to compare or select projects. In Payment-for-Ecosystem-Services schemes, compensation levels are rarely set using these valuation methods.[39]

* A relationship can be inclusion in a transacted good or service, use in production, equivalence with a market good or service, or something else entirely. In the least cost method, for example, the price of a flow of ecosystem services (and thus, through the theory of capital services, its asset value) can be approximated by the cost of replicating the service by other means

BOX 11

THE CHALLENGE OF SIMPLIFICATION

“[C]ollapsing the multi-faceted dimensions of biodiversity into a single unit will necessarily remain

arbitrary and will conflate and obscure the diverging qualities of certain key indices and processes when these measures are decoupled from each other”

- Virah-Sawmy et al., 2014. J. Env. Man. 143:61-70.

3. The Options for Non-Economic ‘Common Unit’ Comparisons

An alternative to monetary valuation is to find or create common units with which to compare outcomes. Identifying common dimension(s) of co-benefits, specifying an aggregation rule to collapse dimensions (see below), and/or eliminating units via standardization are all valid ways to compare outcomes in common terms. The last approach (standardization) can also be thought of as an efficiency measure.

BOX 12

GOAL-SETTING: WHAT TYPES OF PROJECTS SHOULD WE FUND?

Ultimately any safeguard or incentivization system for Natural Climate Solutions will reflect societal valuations. Canadian values about the importance of clean air and water, healthy ecosystems, and diverse, vibrant communities underlie the push to make mitigation projects do more than keep GHG emissions out of the atmosphere.

At the same time, in an ideal world the arbitrary valuations of individuals or special interest groups must not be allowed to drive methodological choices and outcomes, where an evidence-based or science-based approach is preferred. In this context, how can good outcomes be defined?

One way to identify goals for Natural Climate Solutions is to focus on socially identified priorities. Government could utilize existing regulatory commitments to identify positive outcomes for co-benefits. For example, positive biodiversity co-benefits could be identified using Canada's Aichi or 2030 targets under the UN Convention on Biological Diversity, either as simple binary (positive/not positive) or with a ranking system that assigned points for each contribution towards an Aichi or 2030 goal.

The main advantages of this approach are simplicity and flexibility, as regulatory commitments are already made and may be updated or revised to reflect changing societal priorities. The main disadvantage is restricted scope: worthwhile projects may be deemed invalid solely for pre-empting government decision-making, limiting the bottom-up potential of market-based offsets to deliver benefits.

An alternate way to set goals is to rely on scientifically identified values. Government could provide or endorse objective evidence about high and low-value co-benefits. For example, biodiversity co-benefits could be identified using maps of biodiversity-rich areas or COSEWIC lists of species at risk, with positive outcomes identified using simple heuristics (e.g., 'enhancing' habitat or 'increasing' reserve areas).

The main advantages of this approach are objectivity and accessibility: outcomes are inherently scientifically defensible, and no a priori restrictions are set on valid project types. The main disadvantage is an increased need for resources to create or validate necessary evidence.

In practice, any approach to promote Natural Climate Solutions must rely on both objective evidence and social choices about what matters at some stage in the goal-setting process. Smart program design will leverage existing assets wherever possible – and this includes both prior political efforts to identify areas for action and the abundance of high-quality Canadian science that shows areas where action is urgently needed.

Aggregation and eliminating units are often combined in practice. For example, outcomes in different "dimensions" of biodiversity can be put into unitless terms by comparing each against a baseline. This is a form of standardization that converts metrics in incomparable units (e.g, the number of fish and of field mice) into comparable units (e.g., observed population as a fraction of natural population of fish and of field mice). If all dimensions are judged to be similarly important, a simple average is an appropriate aggregation rule. By contrast, a weighted average is an aggregation rule that places greater emphasis on outcomes in some dimensions.

These methods are employed by the best known example of valuing biodiversity in a non-economic common unit: the "habitat hectare" scheme used for biodiversity offsetting in Australia.[40] First, a common physical unit (hectares) is selected for evaluation. Then, each hectare is quality adjusted using a standardization approach. In its original conception, "general vegetation/habitat quality [of a parcel of land] is scored from one (complete retention of natural quality as described by benchmark characteristics) to zero (complete loss)". Note that one dimension is used - the state of natural vegetation,* and standardization is achieved by normalizing with a 'natural' baseline value. Finally, an aggregation rule is applied: hectares of land are summed, using the quality adjustments as weights.

Obviously, the choice of dimensions to measure, the standardization rule used, and the aggregation procedure can all determine the result. For example, the mining company Rio Tinto developed (with IUCN) the concept of "units of global distribution" as a standardization rule in which species abundance is normalized by the entire global population.[41]

This approach will minimize the perceived consequences of any particular case of habitat loss. Similarly, Australia's habitat hectare scheme has been criticized for ignoring scale-dependent effects such as site conservation significant and endangered species viability requirements.[42]

The strength of non-economic common unit comparisons is their practicality and clear connection to physical science. Their weakness is a lack of generality across classes of co-benefits and their lack of specificity within classes – it is difficult to find a non-economic common unit approach that applies to both biodiversity conservation and ecosystem services, for example, or that captures both the dimensions of resilience and naturalness within the class of bio-diversity co-benefits.

4. Multidimensional Comparisons: Can we Compare Co-Benefits Without a Common Unit?

While evaluating co-benefits in a common unit makes comparisons easy, the inherent simplification may obscure vital details. At the same time, methodological choices must be made that may favor particular outcomes, encouraging strategic efforts by special interest groups to achieve biased metrics. An alternative approach is to compare interventions in natural systems across multiple dimensions or classes at the same time. By so doing, more information is preserved – and more detail about outcomes is made explicit when selecting projects. However, because dimensions of a co-benefit remain fundamentally incomparable, only ordinal comparisons (ranking) can be made.

4.1 Qualitative Evaluation: Purely Ordinal Concepts

When fundamentally incomparable dimensions are evaluated, absolute comparisons cannot be made. For example, if an intervention results in gains to water purification and to genetic diversity, there is no way to compare the absolute magnitude of gains in these very different areas. However, *ordinal* comparisons are still possible: in both cases, a gain has been made. All that is necessary for measurement is an 'evaluation rule'- for example, 'no loss in any dimension' or 'gains over time in at least some dimensions'. These are the measurement approaches taken by the leading co-benefit certification standards in voluntary carbon markets (see section 1).

The distinct advantage of a purely ordinal approach to comparison is that tradeoffs do not have to be considered. There is no need to consider the relative importance of outcomes in one dimension to outcomes in other. The weakness of this approach is the imprecision of the resulting measurement: nothing can be said about progress towards important goals (e.g., megatonnes of carbon sequestered, number of species protected) without further examination, and it is not possible to compare proposed projects in terms of their efficiency. Purely ordinal concepts are therefore a simple and robust, but limited, tool, and are better suited for implementing safeguards than incentivizing outcomes.

* Using a 'holistic unit' like general vegetation/habitat quality avoids the need to define another aggregation scheme to evaluate quality on the basis of underlying characteristics such as the abundance of coarse wood debris or the diversity of plant species. However, choices about the importance of these elements still must be made by policy-makers – in this case via the provision of a scoring rubric to habitat assessors. Alberta's Wetland Policy took a similar approach, providing an evaluation rubric to guide expert assessment.

BOX 13

EXAMPLE APPLICATION: BUILDING A 'POSITIVE LIST' FOR TOP-UP FUNDING

Including NBS offsets in Canada's output-based carbon pricing system could deliver more than just low-cost mitigation. Smart policy design can unlock co-benefits, enabling each dollar to deliver towards multiple objectives. The example below shows one way - of many – that the tools discussed in this section could be put together to identify projects on a 'positive list' for funding. For simplicity, assume the base carbon offset is additional, permanent, and not subject to leakage.

Efficiency-based comparison measures offer a route to optimal project selection. First, the set of meaningful outcomes must be defined. Societal goals revealed through legislation, for example (Aichi targets, SARA, etc…) could be used to select classes and dimensions of co-benefits. Then, project proponents must describe delivered co-benefits, and bid on their required top-up price. Finally, the program authority calculates the relative efficiency of all projects (via, for example, Data Envelopment Analysis) and ranks projects from most to least efficient.

Available top-up funding is made available to the most-efficient project first, with residual funding 'cascading' to fund the second-most efficient, and so on. Simple heuristics (funding caps per project or per region) can easily be added to achieve policy targets, and the resulting funding model ensures that top-up spending achieves the most co-benefits per dollar spent. To avoid free-riders submitting low bids for projects that are viable at the base price, co-benefits may be defined to exclude common non-additional cases - or financial need may be audited.

Among the many considerations necessary to make a top-up funding policy successful, asymmetric information and transaction costs are especially pressing. Care must be taken in policy design to select mechanism that reduce the 'information rents' that can accrue to self-interested project proponents (for example, via competitive auctions). Furthermore, the timing of top-up funding and the process for scoping, approving and funding projects must be streamlined with the base offset accreditation – after all, the costs of monitoring and verification are a well-known barrier to participation in offset markets.

4.2 "Efficiency" Concepts

An alternate approach to evaluating outcomes is to view interventions as actions that take inputs (funding) and produce outputs (co-benefits). It is then possible to compare interventions on an efficiency basis, selecting those projects that produce the greatest outputs per unit input. An efficiency approach can be taken to the 'common unit' methods discussed above, but can also be applied to evaluate outcomes on multiple dimensions (or across classes of co-benefits) simultaneously.

However, the problem of incomparable interventions cannot be avoided: where two projects produce fundamentally different outcomes, either common units must be found or created (using the methods described above) or 'dummy dimensions' must be created so that all projects score on the same set of dimensions*.

* Consider the prior example of comparing an intervention in a forest with an intervention in a wetland. Assume the forest project increases the abundance of a threatened species and improves habitat connectivity, whereas the wetland project increases the abundance of a different species and improves water filtration. Both projects can be scored on all three dimensions (threatened species outcomes, habitat connectivity outcomes, water filtration outcomes), but each will have a score of 0 in one category (the 'dummy dimension'). However, comparing outcomes to inputs now creates an efficiency measure. Notice that without imposing further structure outcomes in each dimension are considered equally important – an alternative would be to specify a 'comparison rule' to define some classes as more important than others or to specific a relationship between classes.

A range of techniques are available for conducting efficiency analysis. For example, Cost Utility Analysis divides output by input (cost) to produce a single metric. This technique has been applied to evaluate the efficiency of biodiversity gains,[43] focusing on dimensions of biodiversity (species conservation status) that can be scored using a unitless index (% change in status) and then employing an aggregation rule (summation) to produce a common unit of ('total % gain in biodiversity, all species') which can be divided by total expenditures.

If outputs can be valued monetarily (or approximate values can be estimated), conventional cost-benefit analysis is also an efficiency measure. In this case, the widely adopted INFFER protocol[44] provides a structured framework for ranking and selecting projects*.

A more sophisticated alternative is Data Envelopment Analysis[45] (DEA; Charnes et al., 1993) which is widely used to assess efficiency across multiple inputs and outputs in applications ranging from industrial process control to hospital management. DEA allows outcomes across multiple dimensions to be measured simultaneously, and compares each project to the most efficient project shown to be possible by the observed data. There is a rich literature surrounding the use of DEA. For example, the technique has been applied to evaluate the efficiency of national parks in Italy.[46]

The strength of efficiency measures is their clear integration with policies that aim to maximize the benefits of NBS. For example, ranking possible interventions by their efficiency and providing necessary funding in order of that ranking (a 'cascading' funding model- see Box X) is very similar to a reverse auction in approach and outcome. However, the problem of comparing among dimensions is circumvented, not solved, by choosing to evaluate on all dimensions simultaneously. Furthermore, where many dimensions are considered, technical problems arise: in DEA, for example, many projects may be identified as "fully efficient" if too many types of output are considered. In addition, it may be more difficult to explain these more complex comparison methods.

Evidence-based criteria are essential for selecting NBS projects. Smart policy will select projects that are economically efficient, promote Canada's values-based objectives, and leverage every dollar spent. No perfect method exists to comparing and selecting between projects with fundamentally heterogenous outcomes, but available methods can be adapted to the policy options outlines in this report.

* Project comparisons (ranking) in INFFER requires defining the value of environmental outcomes (e.g., protection of an environmental asset). In contrast to the economic valuation techniques discussed, INFFER does not derive this value. Instead, if values are not known, values may be estimated by subject matter experts. The technique has seen substantial uptake in Australia.

Section 2 - Key Takeaways

- Using economic valuations to compare co-benefits is costly and not recommended for programs that must evaluate many small projects.
- Common-unit measures follow naturally from specific policy goals (e.g., the use of area protected to evaluate progress towards Aichi targets). However, biodiversity has more dimensions than just physical area.
- Past successes with rule-based common unit comparisons that rely on aggregation and standardization offer a practical model for measuring and achieving real gains.
- Efficiency-based methods show great promise for 'incentivization' policy models. Developing these methods is particularly recommended for top-up funding in the context of the federal offset program.

Annex 1: Reverse Auctions in Practice

A review of other jurisdictions demonstrates that reverse auctions can be an efficient mechanism to allocate funds when appropriately designed. Auction design can vary to incorporate elements that address specific challenges such as low-participation rate and strategic bidding.

Created by the Food Security Act of 1985, the United States Department of Agriculture's Conservation Reserve Program (CRP) is the most-extensive private-lands protection program in the United States.[47] CRP establishes contracts with landowners to retire highly erodible and other environmentally sensitive cropland from production.

Landholders submit offers as one-time sealed bids inquiring an annual rental payment based on their coverage practice for a contract period of 10 - 15 years, which will then be ranked by the Environmental Benefits Index (EBI). Single round bids are generally more efficient than multi-round bids because the repetition of the auction increases the chance of strategic bidding as bidders learn more about the distribution of the bids. A bid cap exists based on a parcel-specific Soil Rental Rate to prevent excessive payments. The conservation practices are diverse with grass planting, conservation of living grass, and wildlife habitat as top practices.

In 2018, 9.1 million hectares of land was under conservation contract. The total rental payment for the lands under contract was 1.8 $ billion. (USDA, CRP Enrollment). The average CRP rental payment for registration is $200 per hectare.[48] Between 1985 and 2015, the program prevented 9 billion tons of soil from eroding, reduced nitrogen, and phosphorous runoff relative to annually tilled cropland by 95 and 85 percent, respectively (USDA Conservation Reserve Program Fact Sheet 2015).

Analysis of around 100 tenders in Australia during 2001-2012 shows that among implemented auctions, the majority were single round sealed bidding auctions. In some auction designs, bids were evaluated based on multiple metrics. For instance, the EcoTender trials evaluated the bids based on various objectives such as biodiversity benefits, water quality, and saline land area. EcoTender trials allocated 4.6 $M Aus to 152 bids covering 1684 hectares of land. Although the review of these reverse auctions has shown the relatively robust cost-effective mechanism of funds allocation, political and bureaucratic forces, and low participation rate are among reasons for their limited use.[49]

Australia's Emission Reduction Fund (ERF), established in 2014, is also based on a reverse auction mechanism. Under ERF, bidders submit offers on the volume of the GHG emission reductions they can deliver, timeframes for delivery, and the price they are willing to accept for their achieved emission reduction. The bids are ranked, and the government purchases the lowest bid for emission reduction.

Australia's ERF has struggled to deliver intended emission reductions in the land sector. In 2018, six land-based contracts worth $24 million were canceled as they failed to deliver the carbon reductions[50]. The land-based projects under ERF are limited to native forest protection, tree plantation, native forest regeneration, and soil carbon buildup through improvement in farming practices.

In Canada, reverse auctions for conservation easements in wetlands and grasslands have been conducted by Ducks Unlimited Canada (DUC) in Alberta, Saskatchewan, and Manitoba[51]. The contracts were in perpetuity and the reverse auction was a single-bid uniform price with a hidden reserve price. The uniform pricing disincentivized bidders to bid above their compliance cost.

Landholders bid on two types of sites: Agricultural and non-agricultural conservation easements. The Agricultural easements allow agriculture activity on the land compatible with the conservation objectives of the easement; therefore, they assign a broader range of rights to the landholders. The bids were ranked based on the share of the fair value market of the land. This mechanism helped deal with the problem of low participation from high-value landholders. The uniform price (a key design feature) with payment based on the highest losing bid also discouraged the strategic bidding. Despite the low participation rate, bids revealed the expected willingness to accept (WTA) from landholders.[52] Low participation rates can highlight the trade-offs between strict or complex policy design and practical implementation.

Annex 2: NBS Related Carbon Offset Protocols – Canadian Compliance Markets

Compliance Markets – NCS Related Protocols

Conservation Cropping Protocol | Alberta | 2012 - Present

Scope examples of eligible activities	Description	Methodology
Soil organic carbon from no-till management systems (quantifies annual emissions reductions based on yearly growth in soil carbon Reduced NO2 emissions from soils due to no-till management. Reduced emissions from fewer passes on the farm field with agricultural machinery.	Introduced as a compliance option under the Specified Gas Emitters Regulation (SGER). Offset prices were de facto capped by the carbon price of $15/tonne of CO_2e. Replaced the Tillage System Management offset protocol (active from 2009-2012). Eligibility limited to the Dry Prairie and Parkland Ecozones. Between 2002 and 2016, agriculture-related projects in Alberta removed almost 13 Mt CO_2e – Conservation cropping most widely used of these. The protocol also contains an optional mechanism to quantify emissions reductions from reduced fallow activities undertaken in tandem with zero tillage crop farming. Protocol expires December 31, 2021 based on a 20-year crediting period for conservation cropping using zero tillage.	Permanence risk is addressed by using a reserve discount factor (7.5% for Dry Prairie region and 12.5% for Parkland region). Participants must also track and report on any reversal events. Additionality is estimated using a performance standard baseline (rewards both current and previous adopters). The penetration rate above which adoption of a practice is considered additional is set at 40%. The soil carbon sequestration is discounted based on 2006 sector-level adoption rates. No adjustments made for leakage.

Compliance Offset Protocol U.S. Forest Projects | California | 2011 - Present

Scope examples of eligible activities	Description	Methodology
Reforestation (planting trees and removing obstacles to natural regeneration Improved Forest Management (increasing rotation ages, maintaining high stock rates Avoided Conversion (preventing conversion of forest land to non-forest uses).	Generally speaking, both private and public (state/municipal) lands are eligible for generating offsets. Moreover, landowners who choose to terminate their contracts are required to retire the offset credits, or repay the carbon credits to the offset buyer (with an additional penalty for improved forest management projects). Tree planting and harvesting are eligible activities under avoided conversion projects.	Permanence is addressed through forest buffer accounts (whereby a share of the credits is retained to hedge against the risk of reversals). Additionality is assessed differently by project type. Avoided conversion projects use an opportunity cost approach to determine threat of land conversion; reforestation projects use a financial additionality approach; and improved forest management uses regulatory and performance standard baselines (actions go over above business-as-usual practices or actions required by law). Leakage risk is addressed by deducting approximately 20% of total eligible project credits.

Repealed Protocols

Tillage System Management Offset Protocol | Alberta | 2009 - 2012

Scope examples of eligible activities	Description	Methodology
Soil organic carbon from no-till or reduced till management systems (quantifies emissions reductions based on estimated annual growth in soil carbon). Reduced NO2 emissions from soils due to no-till management. Reduced emissions from fewer passes on the farm field with agricultural machinery.	Introduced as a compliance option under the SGER (see entry on Conservation Cropping protocol for further information). Superseded by the Conservation Cropping Protocol in 2012.	Permanence risk is addressed by using an 'assurance factor' which, depending on the region, ranges from 10-15% for reduced till agriculture, and 7.5%-20% for no till agriculture. Participants must also track and report on any reversal events. Additionality is estimated using a regional performance standard baseline, in which the emissions factors are set according to regionally differentiated 1990 baselines. No adjustments made for leakage.

Protocol for the Creation of Forest Carbon Offsets | British Columbia | 2008 - 2016

Scope examples of eligible activities	Description	Methodology
Afforestation (converting marginal agricultural land, urban areas and degraded industrial sites). Reforestation (planting, seeding and/or assisting natural seed sources). Improved Forest Management (increased sequestration rates, reduced emissions, increasing long-term storage in harvested wood products). Conservation / Avoided Deforestation (avoided conversion to agricultural, residential, commercial or industrial land).	The protocol has since been repealed but some of the approved offsets were grand-parented into B.C.'s subsequent *Greenhouse Gas Industrial Reporting and Control Act (GGIRCA)*. Afforestation/reforestation requires the use of genetically diverse germplasm; prohibits the use of genetically modified trees and imposes limits on the use of non-native species. Avoided logging not considered an eligible conservation/avoided deforestation activity.	Mitigation plan required for addressing risk of reversals (e.g. project-specific buffer pool; multi-party buffer pool or insurance policy). Project-based, financial approach to additionality. Leakage addressed by accounting for and managing project buffer zones (for addressing local leakage) and through the use of provincial base case leakage estimates (regionally differentiated) or through project-specific estimates.

Other forest carbon protocols (not nature-based)

Direct reductions in greenhouse gas emissions arising from changes in forest harvesting practices | British Columbia | 2008 - 2016

Scope examples of eligible activities	Description
Improved forest management (energy savings and reduced wood debris - using portable woodchippers instead of harvesting entire trees with tree length hauling and chipping in a wood room at the mill).	Introduced as a compliance option under the SGER (see entry on Conservation Cropping protocol for further information). Protocol withdrawn as of April 2018.[53]

References

Bennett, K. (2010). Additionality: The next step for ecosystem service markets. *Duke Environmental Law and Policy Forum*, 20(2), 417–438.

Carson, R.T., Flores, N.E., and N.F. Meade. 2001. Contingent valuation: Controversies and evidence. *Environmental and Resource Economics, 19(2):* 173-210.

Charnes A, Cooper WW, Lewin AY, Seiford LM. 1993. Data Envelopment Analysis: Theory, Methodology and Application.Kluwer: Boston, MA

Department of Natural Resources and Environment, 2002. Victoria's Native Vegetation Management; A Framework for Action. Department of Natural Resources and Environment, Melbourne, Victoria.

Duhon, M., McDonald, H., & Kerr, S. (2015). Nitrogen Trading in Lake Taupo: An Analysis and Evaluation of an Innovative Water Management Policy. *SSRN Electronic Journal, (June).* https://doi.org/10.2139/ssrn.2653472

Ecosystem Marketplace. 2018. Voluntary carbon markets insights: 2018 outlook and first-quarter trends. Available online at https://www.forest-trends.org/publications/voluntary-carbon-markets/. Gardner, R. C., & Fox, J. (2013). The legal status of environmental credit stacking. *Ecology Law Quarterly, 40*(4), 713–758.

Fox, J., Gardner, R. C., & Maki, T. (2011). *Stacking Opportunities and Risks in Environmental Credit Markets.* Retrieved from www.epri.com

Government of Alberta. (2018). *Alberta Wetland Mitigation Directive.* Retrieved from http://open.alberta.ca/licence

Government of Canada. (2019). *Carbon Pollution Pricing: Options for a Federal GHG Offset System.* Retrieved from https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/pricing-pollution/Options-GHG-Offset-System.pdf

Government of Ontario. (2019). Aggregate Resources: annual aggregate fees and royalties. Retrieved October 11, 2019, from https://www.ontario.ca/page/aggregate-resources#section-9

Green Analytics. (2018). *Economic Instruments for Conservation.*

ICROA/ICL (International Carbon Reduction and Offset Alliance and University College London). 2014. Unlocking the hidden value of carbon offsetting. Available online at www.icroa.org/Offsets.

Johnston, R.J., Boyle, K.J., Adamowicz, W., et al. 2017. Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists, 4(2): 319 – 405.*

Kahneman, D., J.L. Knetsch, and R. Thaler. 1990. *Experimental tests of the endowment effect and the Coase theorem. Journal of Political Economy, 89)6):* 1325-1348.

Mitchell, R.C., and R.T. Carson. 1989. *Using surveys to value public goods: the contingent valuation method.* New York: Resources for the Future.

National Research Council. 2000. *Watershed Management for Potable Water Supply: Assessing the New York City Strategy.* Available online at https://www.nap.edu/catalog/9677/watershed-management-for-potable-water-supply-assessing-the-new-york.

Noga, W., & Adamowicz, V. (2014). *A Study of Canadian Conservation Offsets: Lessons Learned from a review of programs, analysis of stakeholder perceptions and investigation of transaction costs.* Retrieved from www.sustainableprosperity.ca.

Pitman, N. 2011. Social and Biodiversity Impact Assessment Manual for REDD+ Projects: Part 3 – Biodiversity Impact Assessment Toolbox. Forest Trends, Climate, Community & Biodiversity Alliance, Rainforest Alliance and Fauna & Flora International. Washington, DC.

Poulton, Dave. (2016). *Conservation Offsetting 101: An Introduction.* Retrieved from http://www.aaco.ca/uploads/4/8/2/4/48245677/conservation_offsetting_101_-oct_21_16.pdf

Poulton, David. (2014). *Stacking of multiple environmental credits: An Alberta discussion paper.* Retrieved from http://ssrn.com/abstract=2560656http://ssrn.com/abstract=2560656

Poulton, David. (2015a). *Biodiversity and Conservation Offsets: A Guide for Albertans* (No. 48). Retrieved from https://prism.ucalgary.ca/bitstream/id/44155/BiodiversityOP48x.pdf/;jsessionid=F88A837E9476DE960459907FBB3DFA71

Poulton, David. (2015b). *Key Issues in Biodiversity Offset Law and Policy: A Comparison of Six Jurisdictions.* Toronto.

Poulton, David. (2017). *Navigating the swamp: Lessons on wetland offsetting for Ontario.*

Puzyreva, M., Roy, D., & Stanley, M. (2019). *Case Study Research on offsets for water quality management.* Retrieved from https://www.iisd.org/sites/default/files/publications/offsets-water-quality-management.pdf

Robertson, M., BenDor, T. K., Lave, R., Riggsbee, A., Ruhl, J. B., & Doyle, M. (2014). *Stacking ecosystem services. Frontiers in Ecology and the Environment, 12(3),* 186–193. https://doi.org/10.1890/110292

Richards, M. and Panfil, S.N. 2011. *Social and Biodiversity Impact Assessment (SBIA) Manual for REDD+ Projects: Part 1 – Core Guidance for Project Proponents. Climate, Community & Biodiversity Alliance, Forest Trends, Fauna & Flora International, and Rainforest Alliance.* Washington, DC

Temple, H.J. et al. 2012. *Forecasting the path towards a net positive impact on biodiversity for Rinto Tinto QMM. IUCN and Rio Tinto Technical Series No. 2.* Switzerland: IUN.

Tuncel, T., and J.K. Hammitt. 2014. *A new meta-analysis on the WTP/WTA disparity. Journal of Environmental Economics and Management,* 68: 175-187.

End Notes

1 https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/extent-wetlands.html

2 https://www2.liberal.ca/wp-content/uploads/sites/292/2019/09/Planting-two-billion-trees-and-using-the-power-of-nature-to-fight-climate-change.pdf

3 https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Canada%20First/Canada%20First%20NDC-Revised%20submission%202017-05-11.pdf

4 https://ipbes.net/system/tdf/ipbes_7_10_add.1_en_1.pdf?file=1&type=node&id=35329

5 https://phys.org/news/2019-09-canada-lost-birds-years.html?utm_source=TrendMD&utm_medium=cpc&utm_campaign=Phys.org_TrendMD_1

6 https://www.conservation2020canada.ca/the-pathway

7 https://thenarwhal.ca/canada-commits-historic-1-3-billion-create-new-protected-areas/

8 https://www2.liberal.ca/wp-content/uploads/sites/292/2019/09/Planting-two-billion-trees-and-using-the-power-of-nature-to-fight-climate-change.pdf

9 https://www.canada.ca/en/environment-climate-change/services/nature-legacy/fund.html

10 https://greenbudget.ca/wp-content/uploads/2019/10/Green-Budget-Coalitions-final-Recommendations-for-Budget-2020-November-5-2019-web-site.pdf (page 30)

11 https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/natural-resources-climate-change/natural-resources-climate-change-mitigation/forest-carbon-initiative

12 https://cfs.nrcan.gc.ca/publications?id=35627

13 https://cfs.nrcan.gc.ca/publications?id=35590

14 https://www.canada.ca/en/services/environment/wildlife-plants-species/species-risk/pan-canadian-approach.html

15 https://www.canada.ca/en/environment-climate-change/news/2019/09/canada-funds-52-new-projects-to-protect-and-recover-species-at-risk.html

16 https://hcvnetwork.org/how-it-works/

17 https://www2.gov.scot/resource/doc/93853/0022574.pdf

18 Palm-Forster, L. H., Swinton, S. M., LUPI, F. & SHUPP, R.S. 2016a. Too burdensome to bid: Transaction costs and pay-for-performance conservation. American Journal of Agricultural Economics, 98, 1314-1333.

19 https://www.alberta.ca/alberta-wetland-policy.aspx

20 https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/pricing-pollution/Options-GHG-Offset-System.pdf

21 http://documents.worldbank.org/curated/en/191801559846379845/pdf/State-and-Trends-of-Carbon-Pricing-2019.pdf

22 www.epri.com

23 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2560656

24 https://institute.smartprosperity.ca/sites/default/files/publications/files/Noga%20Adamowicz%20Conservaton%20Offsets%20Oct%202014.pdf

25 Duhon, M., McDonald, H., & Kerr, S. (2015). https://doi.org/10.2139/ssrn.2653472

26 https://www.iisd.org/sites/default/files/publications/offsets-water-quality-management.pdf

27 https://prism.ucalgary.ca/bitstream/id/44155/BiodiversityOP48x.pdf/;jsessionid=F88A837E9476DE960459907FBB3DFA71

28 https://laws-lois.justice.gc.ca/eng/acts/I-2.75/page-3.html#docCont

29 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/guide-to-understanding/chapter-3.html

30 file:///Users/Katherine/Desktop/Metcalf/Draft_Strategic_Assessment_of_Climate_Change.pdf

31 http://www.loggingscars.ca/

32 Virah-Sawmy, M., Ebeling, J., and R. Taplin. 2014. Mining and biodiversity offsets: A transparent and science-based approach to measure "no-net-loss". *Journal of Environmental Management.*, 143: 61-70.

33 Pearce, D. and D. Moran. 1994. The economic value of biodiversity. London: Earthscan Publications Ltd.

34 For a review of best practices, see: Johnston, R.J., Boyle, K.J., Adamowicz, W., et al. 2017. Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists*, 4(2): 319 – 405.

35 See for example: Carson, R.T., Flores, N.E., and N.F. Meade. 2001. Contingent valuation: Controversies and evidence. *Environmental and Resource Economics*, 19(2): 173-210.

36 Obtaining high quality Willingness-To-Pay (WTP) values via experimentation, for example, typically costs over $100k per project. See for example: Cullen, R. 2009. Is economics being outcompeted in environmental decision making? Self-published whitepaper.

37 A recent review shows that estimates obtained by WTA methods are on average six times greater than those obtained by a WTP approach. See: Tuncel, T., and J.K. Hammitt. 2014. A new meta-analysis on the WTP/WTA disparity. Journal of Environmental Economics and Management, 68: 175-187.

38 National Research Council. 2000. Watershed Management for Potable Water Supply: Assessing the New York City Strategy. Available online at <https://www.nap.edu/catalog/9677/watershed-management-for-potable-water-supply-assessing-the-new-york>.

39 Ferraro, P.J. 2011. The future of payments for environmental services. *Conservation Biology*, 25(6): 1134-1138.

40 Department of Natural Resources and Environment, 2002. Victoria's Native Vegetation Management e A Framework for Action. Department of Natural Resources and Environment, Melbourne, Victoria.

41 Temple, H.J. et al. 2012. Forecasting the path towards a net positive impact on biodiversity for Rinto Tinto QMM. IUCN and Rio Tinto Technical Series No. 2. Switzerland: IUN.

42 Virah-Swamy et al., 2014; but see Dep't Nat. Res. Environ, 2002: Appendix 4 for a heuristic "safeguard" approach to these issues

43 Cullen, R., Moran, E., and K. Hughey. 2005. Measuring the success and cost effectiveness of New Zealand multiple-species projects to the conservation of threatened species. *Ecological Economics*, 53: 311-323.

44 Pannell, D., Roberts, A., Park, G., Alexander, J., Curatolo, A., and S. Marsh. 2012. Integrated assessment of public investment in land-use change to protect environmental assets in Australia. Land Use Policy, 29: 377-387

45 Charnes A, Cooper WW, Lewin AY, Seiford LM. 1993. Data Envelopment Analysis: Theory, Methodology and Application.Kluwer: Boston, MA

46 Bosetti, V., and G. Locatelli. 2006. A data envelopment analysis approach to the assessment of natural parks'

47 Conservation Reserve Program, Retrieved from https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index

48 CRP Enrollment and Rental by state 1986-2018

49 Rolfe, J., Whitten, S. & Windle, J. 2017. The Australian experience in using tenders for conservation. Land Use Policy, 63, 611-620

50 https://www.theguardian.com/australia-news/2018/nov/13/emissions-reduction-fund-contracts-worth-24m-cancelled-after-failure-to-deliver-cuts

51 https://www.ducks.ca/resources/landowners/conservation-easements/

52 Brown, L. K., E. Troutt, C. Edwards, B. Gray and W. Hu. 2011. A uniform price auction for conservation easements in the Canadian prairies. *Environmental and Resource Economics 50 (1): 49– 60.*

53 https://www.ekginc.com/blog/ohs-environmental-legislative-updates-april-2018

ACKNOWLEDGEMENTS

The authors wish to thank the Metcalf and McCall MacBain Foundations for their funding and support for this project. Key points raised by participants during Smart Prosperity Institute's workshop on Nature-Based Solutions and Biodiversity on Nov 18, 2019 are reflected in this report. Special thanks to Ronnie Drever at Nature United for his review and writing for the albedo text box. Thank you also to Scott McFatridge and Paige Olmsted for their review, to Stewart Elgie for thought leadership, and to Eric Campbell and Mathias Schoemer for editing and communication support. Production and design by Mathias Schoemer.