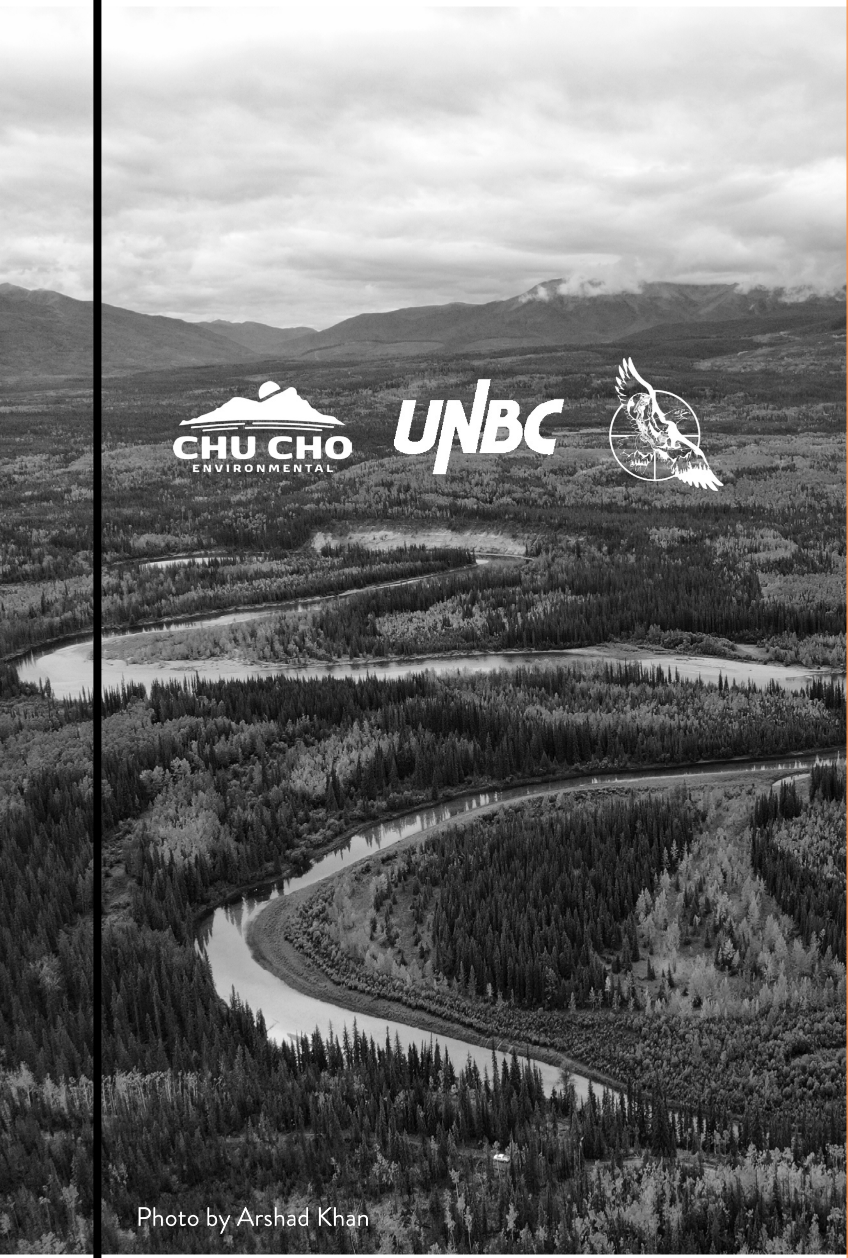
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Systematic Conservation Planning in Tsay Keh Dene Territory:

Incorporating Climate Change and Interweaving Traditional Ecological Knowledge

An Executive Summary by
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Office

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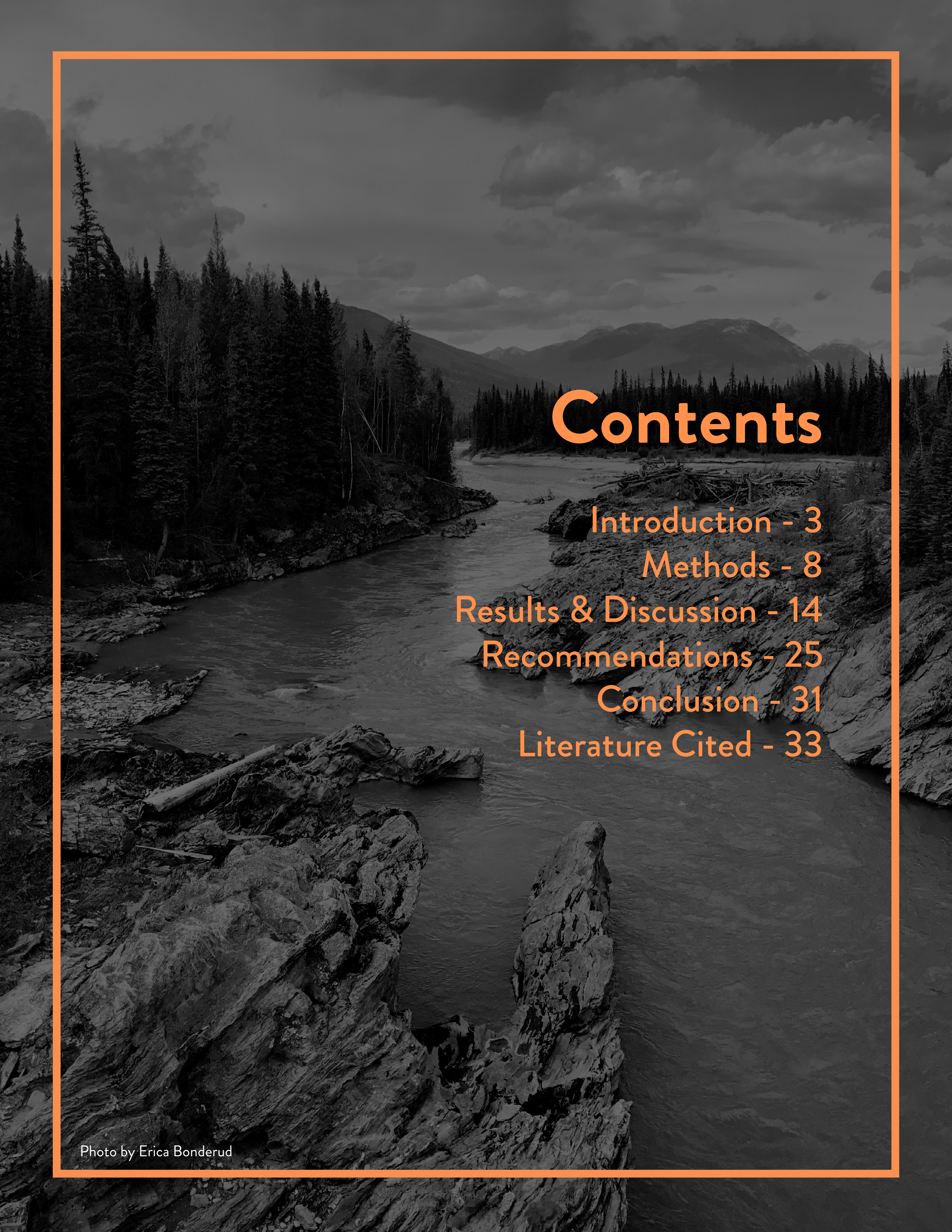
Contents



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INTRODUCTION

Conservation Planning Need for the Tsay Keh Dene Nation

In the twenty-first century, much of the global conservation planning response to development pressures has been focused on the designation and management of parks and protected areas (Maxwell et al., 2020). Only 9% of Tsay Keh Dene Territory is currently under provincial protected status, though the Nation has recently declared an Indigenous Protected and Conserved Area in the Ingenika River valley. The largest of these protected areas (Omineca) is under 1,000 km^2 – well below minimum thresholds for species persistence of wide-ranging mammals (>3,000 km^2) (Gurd & Nudds, 1999; Newmark, 1995; Wright, 2016). While protected areas are an increasingly vital tool to combat loss of biodiversity and the climate crisis, conservation planning must occur across all land management systems and encompass a wide range of management tools and approaches.

The intensity of current resource development in the Territory is such that the Nation is often overwhelmed by the number of referrals for resource extraction activities that they receive. These referrals are, by their nature, limited in focus both to a specific geography and to a single industry or development. As a result, referral comments provided by the Nation are often site-specific and limited in scope. The Nation would like to take a much broader perspective in planning and managing, including being able to contextualize individual referrals within a larger scale conservation context (Tsay Keh Dene Nation, personal communication, September 30, 2019). To that end, Tsay Keh

Dene Nation initiated a research project in collaboration with the University of Northern British Columbia.

Systematic Conservation Planning, Climate Change, and Traditional Ecological Knowledge

Systematic conservation planning (SCP) is widely considered the most effective method for designing wide, regional conservation approaches, including the identification of protected areas and other ecological networks (Pressey et al., 2007). The success and effectiveness of SCP can be attributed to its efficiency in using limited resources to achieve conservation goals, its flexibility and defensibility in the face of competing land uses, and its accountability in allowing decisions to be critically reviewed (Margules & Pressey, 2000). SCP uses detailed biogeographical information and selection algorithms to identify priority conservation areas (Knight & Cowling, 2007; Watson et al., 2011). It strives to move the prioritization of conservation lands beyond opportunism and toward scientific defensibility and improved efficacy (R. L. Pressey et al., 1993). Furthermore, SCP supports the identification of conservation networks that represent regional species and ecosystems diversity, are comprised of enough habitat of specific types to maintain viable species populations, enable continued community and population processes (including shifts in species' ranges), and allow natural patterns of disturbance (Baldwin et al., 2014).

Explicitly incorporating climate change as part of the systematic conservation planning process is now possible. As the field expands its scope and perspectives, approaches become more effective at incorporating previously poorly understood or connected variables (Mann, 2020). With the widespread availability of emission scenarios and reliable climate change data, the SCP framework can incorporate climate information and evolve into a climate change-conscious approach to conservation planning (Stralberg et al., 2020).

This climate-conscious approach involves looking at areas of biotic refugia, or habitat that will remain viable and desirable for species despite climate change (Michalak, Lawler, et al., 2018). Another aspect of this approach is to consider climate velocity, which quantifies how far species will have to travel from a given area to find similar habitat in the future (forward velocity), as well as how far other species will have to travel to populate that same area in its now altered state (backward velocity) (Carroll et al., 2015). One of the first projects to undertake a climate-conscious conservation planning approach in Canada has been done in British Columbia's Peace Region (Mann, 2020). Methods developed and tested in that project were used to inform this project's approach.

This research project is unique from Mann's (2020), however, in that it was developed in conjunction with a First Nation. Indigenous-led conservation initiatives are gaining momentum in Canada and elsewhere in the world through the creation of Indigenous Protected and Conserved Areas (IPCAs) (Zurba et al., 2019). Establishing conservation areas is just one way to protect biodiversity, with other designations like Old Growth Management Areas (OGMAs) and Ungulate Winter Range (UWR) also serving as options in British Columbia. These sorts of initiatives help to further the selfdetermination of Indigenous peoples, creating conservation areas that embody their own biodiversity and cultural values as opposed to the colonial processes of the past that centered on a people-free 'wilderness'. By initiating and guiding this project, the Tsay Keh Dene Nation ensured that their values informed this research by helping scope it from the outset and providing input at each step along the way.

Research Purpose

The purpose of my research project was to explore which areas in Tsay Keh Dene Territory have high conservation value – both ecologically and culturally – landscape connectivity, and resiliency to climate change. I used the systematic conservation planning framework and interwove Traditional Ecological Knowledge (TEK) throughout by taking a critical GIS perspective and community-led approach to identifying important conservation lands in the Territory for the Nation's consideration. By recognizing GIS as a colonial tool shaped by the Western scientific spatial understanding of the world, I assisted the Nation in the form of counter-mapping – using GIS technology to empower a community and share an accessible and defensible expression of their conservation goals. By allowing Tsay Keh Dene values to shape this process, local voices, views, and understandings were etched into this work (Burkhart, 2018).

The result was an actionable systematic conservation plan that assists the Nation with routine resource extraction referrals as well as long-range land use planning decisions. While the Nation already possesses a great deal of GIS capacity, this project complemented its strengths and provided a novel aspect to their geospatial information and conservation planning efforts. The end product included a set of maps and an updatable model identifying the locations of key ecological and cultural values within Tsay Keh Dene Territory that took climate change and connectivity of lands into account. Planning and management of the Territory for cultural, ecological, or economic purposes will be made easier and more defensible with an SCP framework in place.

METHODS

Project Formulation and Study Area

This research project first sought to identify which portions of Tsay Keh Dene Territory have the highest conservation value both now and in the future. Next, it examined how to explicitly include connectivity within the systematic conservation planning framework. Finally, it explored which stages of the SCP process provided an opportunity for the interweaving of Traditional Ecological Knowledge to produce a more inclusive conservation plan (Figure 1). To address these questions, I used a modified SCP framework originally outlined by Margules and Pressey (2000) and supported by community input and Traditional Ecological Knowledge to assess Tsay Keh Dene Territory. This meant including input from the Nation whenever possible to enhance this community-initiated research project (Wilson, 2009).

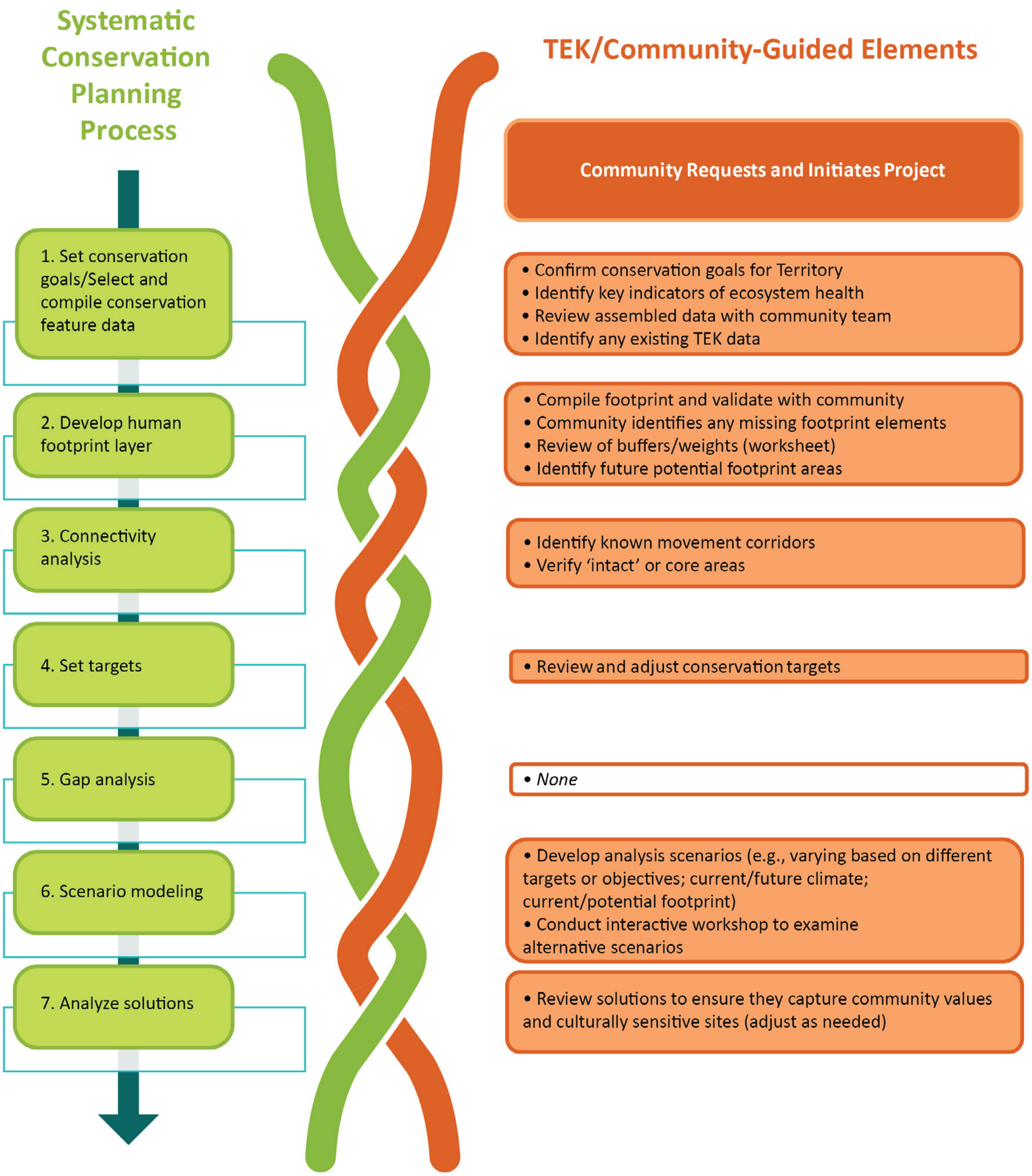

Figure 1. The Systematic Conservation Planning process and points for community guidance and the interweaving of Traditional Ecological Knowledge.

Selecting a relevant study area was essentially Stage 0 of the SCP process given its ecological relevance and downstream ramifications. I initially chose to use the Nation's Territory as my study area, as it is both the Tsay Keh Dene's ancestral lands and the focus of much of the environmental work performed by the Nation and Chu Cho Environmental. The appropriateness of this extent was assessed with the Nation as part of establishing conservation goals for the SCP in Stage 1 of the process. The study area was ultimately built-out with caribou herds and supplemented with important watershed groups to be broader and more ecologically focused (Figure 2).

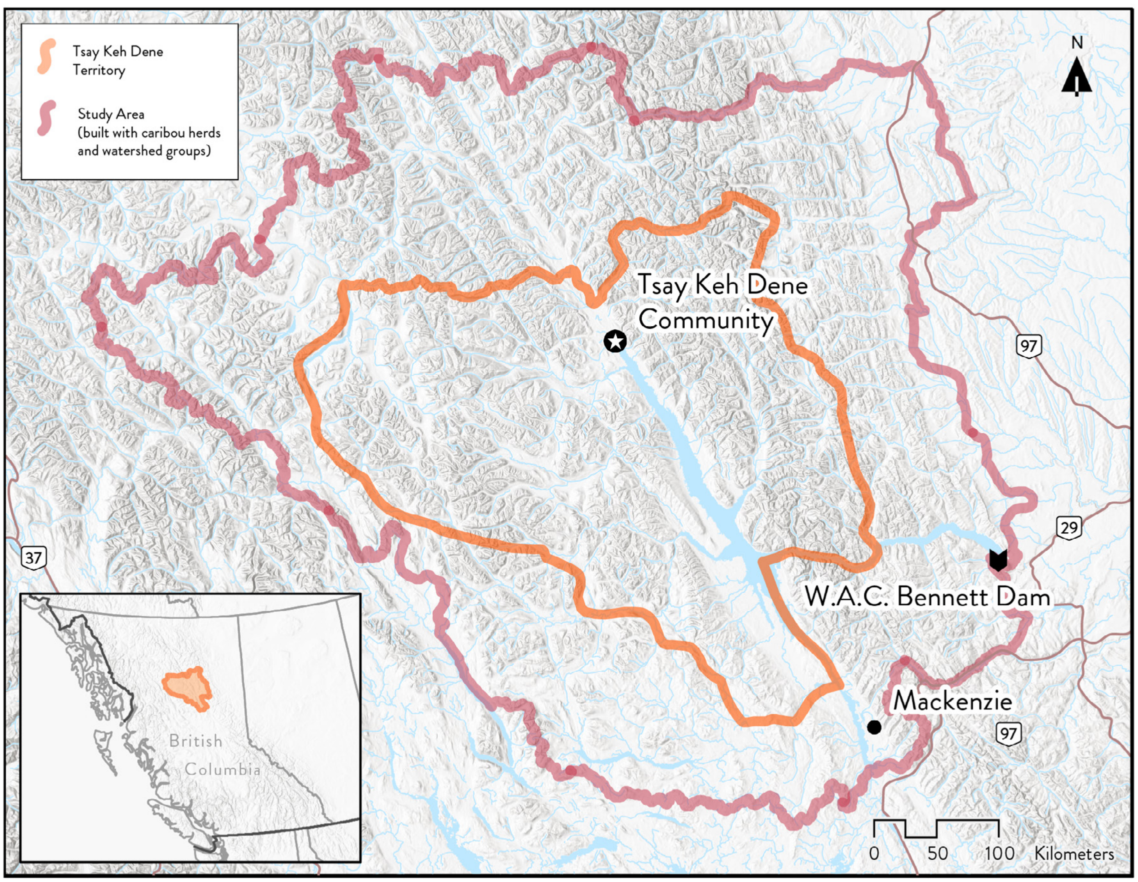

Figure 2. Contextual map showing the selected study area in relation to Tsay Keh Dene Territory.

Conservation Goals, Feature Selection, and Target Setting

The SCP process formally begins with the development of conservation goals for an area, so I first collaborated with the Nation to set goals for the greater territory. The Nation voiced seven goals for this systematic conservation planning effort to achieve:

1. Ensure the direction of systematic conservation planning reflects the vision and goals of the Tsay Keh Dene Nation. Community engagement will provide guidance, support a greater understanding of culturally important areas and values, and inform refinements to this work.
2. Represent the full range of natural ecosystem variation across the Territory.
3. Identify and prioritize ecologically intact, high biodiversity habitats.
4. Identify and prioritize high-value habitat for priority plant, fish, and wildlife species.
5. Identify and prioritize rare ecosystems for conservation.
6. Identify and prioritize connectivity corridors of lands and waters across the landscape.
7. Incorporate an understanding of ecosystem shifts due to climate change into long-term resiliency planning, including identification of climate refugia.

The next step was selecting which features on the landscape help attain those goals. I curated an initial set of conservation features based on previous work to present to the Nation for refinement (Table 1). I then gathered spatial data for the agreed-upon conservation features in a GIS environment, utilizing provincial and federal government, academic, and Nation sources, as well as TEK-sourced data whenever it was available. Next, I delineated areas of human footprint with location and weighting input from the Nation in order to quantify connectivity between protected areas and across the broader landscape. I then set targets for the selected conservation features based on ecological best practices and prior SCP work and reviewed the targets with the Nation in an interactive format utilizing *prioritizr*, a conservation prioritization software.

Next, I reviewed the existing network of protected areas to quantify how well they met those targets. Finally, I used *prioritizr* to identify a suite of ecologically and culturally valuable areas that are ideal for the present-day climate, as well as the projected climates of the 2050s and 2080s. These outputs are known as 'conservation solutions' and provide comparisons between present and future scenarios to allow decision-makers to select areas with the greatest resiliency for conservation action.

Coarse-Filter Features		Description
Abiotic	Land Facet Diversity	Diverse combinations of slope, aspect, elevation and landform
	Land Facet Rarity	Rare combinations of slope, aspect, elevation and landform
Environmental	Elevational Diversity	Cluster of varying elevations
	Ecotypic Diversity	Diverse Ecological Land Units (made up of physical features, climate, and land cover type)
	Heat Load Index Diversity	Diverse collection of solar radiation exposure (i.e. how hot or cool an area is)
Biotic	(Disturbance)-(BEC Zone)-(Age/Burned) Ex 1: NDT1-ESSF-Burned Ex 2: NDT2-SBS-Mature/Old	Combination of disturbance, Biogeoclimatic Ecosystem Classification Zone, and age/burn history of tree stands to meet biodiversity goals from the Biodiversity Guidebook (B.C. Environment, 1995)
	Rare BEC Zones	Rare occurrances of BEC subzone variants in the territory
Fine-Filter Features		**Description**
Species	Grizzly Bear	Capable habitat for grizzly bear, enhanced with TEK
	Bull Trout/Fish	Critical habitat for bull trout focusing on spawning and juvenile rearing sites; enhanced with TEK on bull trout and other fish species
	Fisher	Suitable habitat for fisher based on denning, resting, moving, and foraging needs
	Caribou (by herd)	High quality habitat for caribou by herd, enhanced with TEK
	Moose	Year-round habitat for moose, enhanced with TEK
	Stone Sheep	Suitable habitat for Stone sheep, enhanced with TEK
	Mountain Goat	Suitable habitat for mountain goat, enhanced with TEK
	Wolverine	Suitable habitat for wolverine
	Bank Swallow	Suitable habitat for bank swallow
	Barn Swallow	Suitable habitat for barn swallow
	Western Toad	Suitable habitat for western toad
	Horned Grebe	Suitable habitat for horned grebe
	Little Brown Myotis	Suitable habitat for little brown myotis
	Northern Myotis	Suitable habitat for northern myotis
	Olive-Sided Flycatcher	Suitable habitat for olive-sided flycatcher
	Rusty Blackbird	Suitable habitat for rusty blackbird
Special Features	Wetlands	Wetlands by size of complex
	Lakes	Lakes by size
	Karst Deposits	Cave ecosystems based on likelihood of occurrence
Climate Change Features		**Description**
Migration	Backward Velocity 2055	Distance from a projected 2055 climate location back to analogous existing climate locations
	Backward Velocity 2085	Distance from a projected 2085 climate location back to analogous existing climate locations
	Forward Velocity 2055	Distance from a single source to multiple projected 2055 climate analogs
	Forward Velocity 2085	Distance from a single source to multiple projected 2085 climate analogs
	Climate Corridors	Connections between current and future locations of a climate type
Refugia	Cool Headwater Refugia	Areas predicted to have a mean annual temperature of <1°C by 2080
	Climatic Refugia	Areas where climate-threatened species can continue to exist or readily colonize
	Biotic Refugia	Climatic refugia that are further informed with biological thresholds
Misc.	Bird Richness	Predicted summer habitat for 604 climate vulnerable bird species under a 3°C warming scenario
	Carbon Storage (above and below ground)	Above and below ground carbon storage
Cultural Features		**Description**
	Sites of Cultural Importance	TEK-sourced point data on habitation, subsistence, transportation, wildlife, and cultural/spiritual locations
	Cultural/Spiritual Areas	TEK-sourced polygon data on cultural areas like burial sites, medicinal plant locations, battlegrounds, campsites, and teaching places
	Subsistence Areas	TEK-sourced polygon data on subsistence areas like berry picking sites, hunting grounds, and fishing holes
Connectivity Features		**Description**
	Linkage Mapper	Highly connected areas between existing and proposed protected areas
	Omniscape	Highly connected areas throughout the entire landscape

Table 1. List of Conservation Features used in analysis.

RESULTS AND DISCUSSION

Present-Day Focal Areas

The present-day solution encompassed 59% of the greater territory study area (Figure 3). Given its focus on existing high-quality habitat for a broad collection of species, the solution contains clusters along both river valleys and moderate to high elevation mountain ranges. River valleys of note include the Omineca, Ospika, Mesilinka, and Ingenika. Important montane areas include the northern Misinchinka Ranges and Wolverine Range in the southern extent of the study area, as well as the Omineca Ranges west of Kwadacha in the north.

There were five focal areas representing clusters of high-value conservation lands identified by the tool outside of existing and proposed protected areas. The first was the Omineca River valley (Area 1) connecting Sustut and Omineca Provincial Parks, likely selected because it contains bull trout habitat and low to moderate elevation caribou habitat – both features with very high targets. As the most linear of the five identified areas, protecting this area would not only safeguard these species' habitat, but also provide a crucial connectivity corridor for wildlife between sizable protected areas in the region. This area is also at the interface of the Chase and Wolverine caribou herds, and could contribute to gene flow among these threatened populations (Roffler et al., 2012).

The next focal area was the Ospika River valley and adjacent mountain ranges (Area 2) that contain karst deposits and high-quality habitat for a great deal of focal species (fish, fisher, moose, three herds of caribou, Stone sheep, mountain goat, wolverine, bats, and birds). Protecting this area would not only conserve these species' habitat, but also protect a number of cultural/spiritual areas of the Tsay Keh Dene, as the Ospika, or 'Əsbagah, River valley is of great importance. Additionally, this somewhat linear focal area could serve as a connectivity corridor for wolverine between Redfern-Keily and Graham-Laurier Provincial Parks.

The Mesilinka River valley south of Chase Provincial Park (Area 3) was selected for its abundance of burned Engelmann Spruce–Subalpine Fir forest stands with infrequent stand-initiating events – a feature with a 100% target. While these young, biodiverse forest stands were the reason for this area's selection, the area is also home to fisher, bull trout, moose, and caribou habitat. Protecting this area would add roughly 1,000 km^2 of habitat for fire-obligate species and contain features like burned snags that are not found in young managed forests (Curtis, 2018). This addition would also complement the adjacent forests found in Chase Provincial Park and the proposed Ingenika Conservation and Management Area while also building out the conservation complex.

The northern Misinchinka ranges (Area 4) house both karst deposits and a number of territorially-rare BEC subzone variants, but the leading cause of this selection was likely the fact that it holds high-quality moderate elevation habitat for the Klinse-za caribou herd. This finding confirmed the location of a portion of the Caribou Conservation Partnership Agreement between British Columbia, Environment and Climate Change Canada, West Moberly First Nation, and Saulteau First Nation (Environment and Climate Change Canada et al., 2020). While the areas identified in both efforts largely overlap, my findings suggest that the governments lower their elevation threshold to include a broader portion of the mountain range. While this change adds only slightly more land to an industry moratorium, it significantly reduces the edge-to-area ratio of the patch, therefore increasing vital interior habitat for Klinse-za caribou – one of the focal herds of the partnership agreement.

The final focal area is in the Omineca Mountains west of Kwadacha (Area 5), nestled between the Ingenika Conservation and Management Area, Finlay-Russel Provincial Park, and Tatlatui Provincial Park. This region has several high-value wetlands complexes, as well as high-quality habitat for the Thutade caribou herd, moose, and Stone sheep that likely led to its selection. There is currently only one significant resource road in the area for mining and forestry. Protecting this entire area – or at least the highly connected corridors between the aforementioned protected areas – would minimize further road-building and reduce fragmentation. It would also create a robust conservation network with a complex that includes Mount Edziza, Stikine River, Spatsizi Plateau Wilderness, and Chase Provincial Parks, Gladys Lake Ecological Reserve, and Pitman River and Chukachida Protected Areas. This network would span over 400 km from Chase Provincial Park in the southeast to Mount Edziza Provincial Park in the northwest.

The placement of the proposed Ingenika Conservation and Management Area (CMA) was also broadly confirmed by the present-day SCP solution – an important finding given the deep cultural bonds the Tsay Keh Dene have to this area. Containing several major river valleys, this area contains high-value wetlands complexes and habitat for moose, fisher, western toad, bats, and birds. The moderate to high elevation areas found in this region contain high-value caribou habitat for the Thutade and Chase herds. The Nation has been working specifically to recover the population of the Chase herd, and this solution includes hundreds of square kilometers of habitat within their range. This SCP's affirmation of the Ingenika CMA's placement is vital, as the Tsay Keh Dene have a profound connection with the caribou, or wədzih. The concurrence of the conservation solution with the Nation's proposed conservation and management area boundary further validates their efforts.

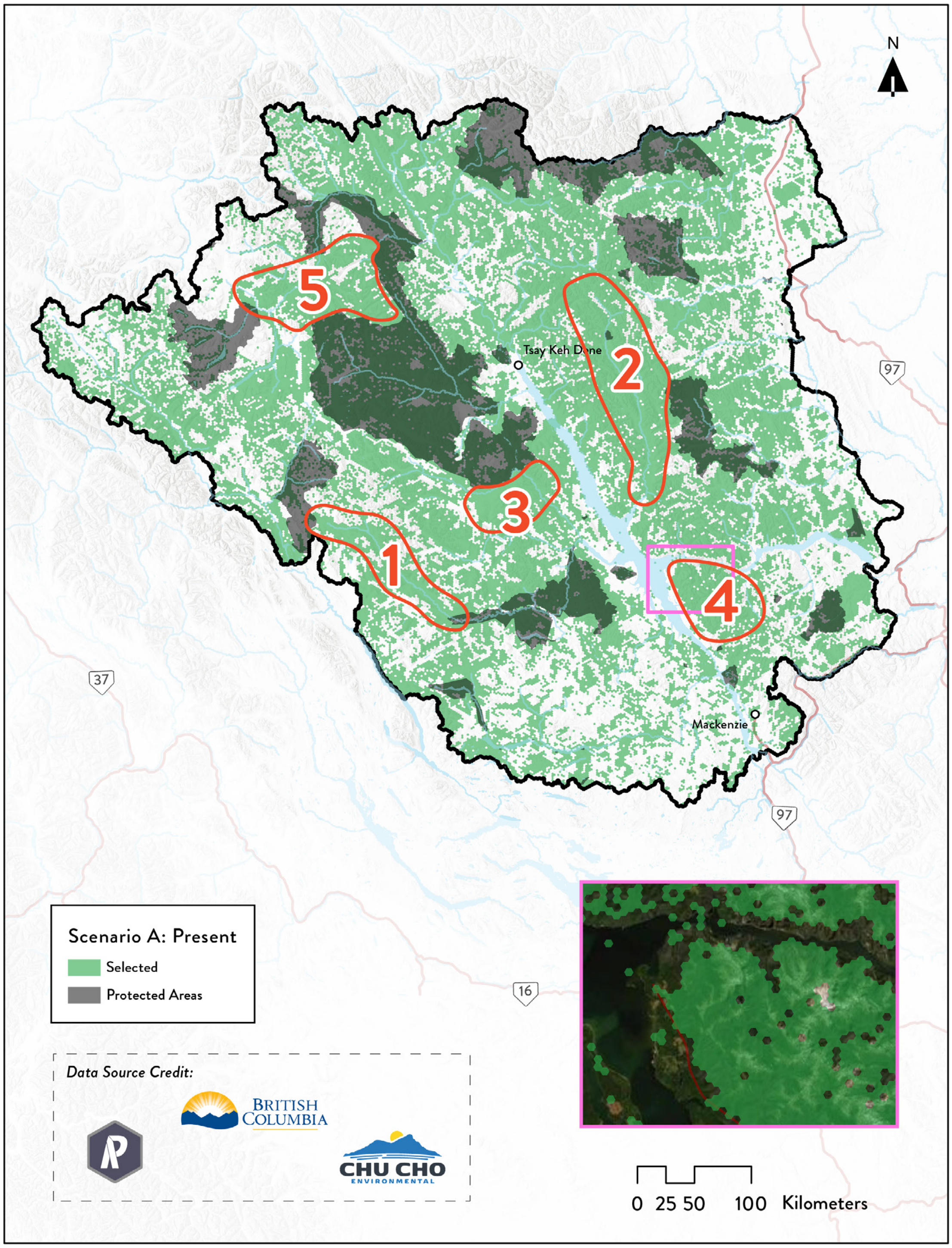

Figure 3. Focal areas (outlined in orange and numbered) and protected areas overlaid with the spatial extent of the conservation solution for Scenario A: Present-day Conservation within the Greater Tsay Keh Dene Territory Study Area; inset represented by pink frame.

Future Focal Areas

Areas identified as biodiverse or otherwise containing high conservation value today may look very different 30 and 60 years from now. Using conservation-focused metrics based on the best climate change predictions available allows us to identify which areas are predicted to remain or become ecologically valuable in the future. When these areas overlap with areas identified for their present-day conservation value, they are considered ecologically valuable *and* climate-resilient and should be further prioritized.

The future-focused solutions each encompassed 52% of the greater territory study area (Figure 4). Given their emphasis on future climates, moderate to high elevation areas are well represented as they serve as refugia in a warming landscape. Clustering is quite evident in these solutions, particularly in the Rocky Mountains along the eastern shores of the Williston Reservoir. Additional clusters can be found along the Skeena River, in the Muskwa Ranges west of Redfern Lake, and along the Finlay River.

While these solutions share many of the same focal areas with the present-day solution, they contain a few unique groupings of values. The first is in the southern Muskwa Ranges between the Ospika and Peace Arms (Area 1), likely selected for its rare land facets, elevational diversity, heat load index diversity, low backward velocity, and carbon storage. Protecting this area would provide a link to Graham-Laurier Provincial Park and safeguard climate resilient habitat for wolverine, grizzly bear, and the Graham caribou herd. Furthermore, this area contains regionally significant carbon storage, a crucial ecosystem service. Keeping carbon sequestered is a widely-accepted protected areas strategy to mitigate climate change globally (Mitchell et al., 2021).

The other novel focal area is in the Omineca Mountains on either side of the Skeena River (Area 2). Similar to the previous region, this area was likely chosen due to its rare land facets, elevational diversity, low backward velocity, and carbon storage; however, low forward velocity also likely played a role in this area's selection. The climate change implications of protecting this area are twofold: the valleys of the Skeena River and its tributaries are carbon storage hotspots, while the surrounding higher elevation mountain ranges are climatic refugia.

The placement of the proposed Ingenika Conservation and Management Area was less substantiated by the 2050s and 2080s solutions; however, its Cultural Epicenter subunit was almost entirely selected given its climate resiliency, as was the western half of the Management Area subunit. This is beneficial, as the Cultural Epicenter of the Ingenika is the portion that is planned to receive legal protections, while the rest will be heavily managed to preserve values but not formally protected. This finding provides climate-conscious Western scientific justification to parallel the cultural and spiritual value of this area as the Nation campaigns for an official conservation designation.

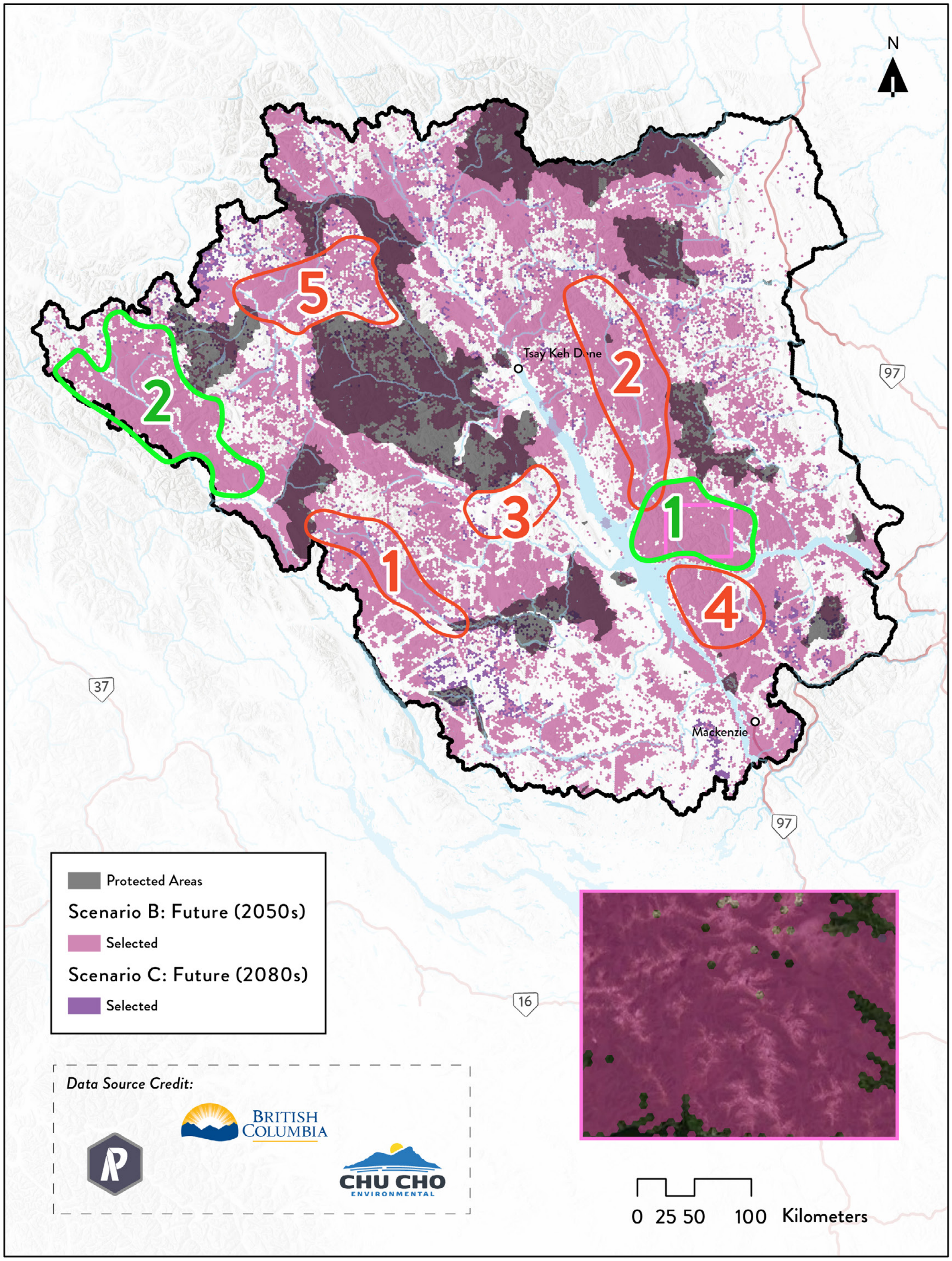

Figure 4. Climate focal areas (outlined in green and numbered) and protected areas overlaid with the spatial extent of the conservation solution for Scenarios B: Future (2050s) and C: Future (2080s) Conservation within the Greater Tsay Keh Dene Territory Study Area; Present-day focal areas outlined in orange for comparison purposes; inset represented by pink frame.

Connectivity

Landscape connectivity has been recognized as a crucial ecological component of systematic conservation plans, but most efforts to quantify permeability of the landscape to date have used it as a post-hoc or supplementary analysis rather than a core component of the model (Fajardo et al., 2014; Mann, 2020). I incorporated connectivity explicitly in my model by using current flow metrics from tools called Linkage Mapper and Omniscape that employ electric circuit theory and relative resistance. My goal was to capture generalized landscape connectivity, which looks at the structure of the landscape for a generalized species as opposed to structural connectivity for a specific species or functional connectivity for a specific species based on movement data. Linkage Mapper looks at connectivity between protected areas, while Omniscape looks at the connectivity of the landscape overall. The outputs of both tools were used to inform 'locked-in' options for the SCP tool that ensure a degree of connectivity in a conservation solution.

Linkage Mapper is best suited for finding paths between islanded protected areas in a highly fragmented landscape and can thus provide valuable insight for the more developed southeastern portion of the study area. Omniscape is preferable in this geography, however, as it provides more meaningful insights in a relatively intact landscape such as this. It identified important movement corridors in both intact river valleys and mountainous areas that are not prohibitively steep. Conservation initiatives that have connectivity in mind should consider one of these locked-in options to ensure that important movement corridors are captured. There were two scenarios in the thesis that considered connectivity.

Interweaving of Traditional Ecological Knowledge

The most novel and challenging portion of this project was determining how to effectively and inclusively interweave Traditional Ecological Knowledge and community input with the SCP process. As Western and Indigenous worldviews can sometimes appear to be at odds, blending these two ways of knowing in a manner that is respectful to TEK's sacred and cosmological origins while adhering to SCP methodology proved to be a delicate balance at times. While I was in regular contact with the Nation and working in their office throughout the process, I had to remain careful not to corrupt this knowledge by using it in a way that it was not intended.

Community-based research is more involved than a strictly academic exercise by virtue of listening to more voices; however, the additional time and effort required results in a more meaningful and fulfilling project with a greater chance of uptake and real-world impact (Strand et al., 2003). This is especially true in an Indigenous context, where a cross-pollination of perspectives and marrying of two ways of knowing holds real potential for better conservation outcomes if navigated thoughtfully (Polfus, 2018). Building relationships, holding workshops, and fostering productive discussions certainly extended the amount of time required to complete this project, but were vital steps in producing a plan that reflected the visions and goals of the Tsay Keh Dene Nation. Heinemeyer et al.'s (2003) work with the Taku River Tlingit First Nation is a great example of taking a TEK-driven SCP even further with several community workshops and elder interviews to create TEK-based wildlife spatial data – something this effort could replicate given more time.

The main theme that emerged from this community-led approach to the SCP process was the importance of providing sufficient context and conveying the implications of each decision that had to be made. The staff's experience in navigating both Western and Indigenous knowledge was particularly indispensable in the target setting stage, as quantifying the relative importance of features is challenging enough on its own. Undertaking a task that can appear contradictory to the underlying beliefs of the community further complicated the matter, but it is a necessary step in the SCP process. Hearing staff perceptions of community values towards wildlife and ecosystems helped translate priorities into numeric targets, and having the Nation initiate a survey of community members that ultimately backed up those claims with data was affirming.

RECOMMENDATIONS

This research analyzed conservation value across greater Tsay Keh Dene Territory and served to both confirm ongoing conservation efforts and identify where future initiatives could be focused. The Nation should perform validation of these findings to ensure that they are well-founded, but then there are countless possibilities for how they can apply the tool to future use cases to meet their needs. In particular, the scenario stack solution (an overlay of all six scenarios ran for the thesis) should be referenced in conservation efforts, as it combines a number of relevant scenarios to delineate which portions of the Territory meet goals on present-day biodiversity, climate change, and connectivity.

Validation

This entire process is a simulation, and so any conservation solution will need to be verified and validated before decisions are made on the ground. One final way to include local, Indigenous knowledge is to have members of the Nation validate the conservation solutions to ensure that the areas they deem to be ecologically or culturally significant are properly captured in the analysis. The solutions will also require increased scrutiny and potential site visits when local decisions are being made. Initial discussions have taken place to have a Chu Cho staff member who lives in the community perform TEK validation by plotting results on maps and sitting down with elders to discuss findings and mark up the maps. This exercise could serve to endorse or challenge research findings but could also further develop a TEK-SCP methodology by formalizing this interaction and making it part of the interweaving process.

A supplementary approach to validation could also be performed with auxiliary data. These could be spatial datasets that depict an aspect of conservation value, but for one reason or another do not merit inclusion in the tool itself. For example, if reputable elk habitat suitability data is developed in an adjacent area but does not cover the entire extent of the study area, it could be used as an overlay. This allows the user to validate a conservation solution for its elk potential without having to incorporate that data within the tool explicitly.

Another potential validation dataset could be a conservation plan performed by a neighbouring First Nation. This could identify areas of mutual interest, foster cooperation, and potentially lead to conservation designation and co-management efforts like the West Moberly and Saulteau First Nations in their Caribou Conservation Partnership Agreement (Environment and Climate Change Canada et al., 2020). For example, the northern periphery of the study area overlaps with the Kaska Dena's Dene K'éh Kusān IPCA, allowing for a potential partnership for conservation efforts in the region (Dena Kayeh Institute, 2019).

Finally, the Tsay Keh Dene Nation is in the process of performing archaeological work within the Territory, though this effort is not yet finalized. Spatial data from this effort could also be overlaid with solutions to validate whether culturally important areas beyond those explicitly included in the tool were captured in a solution. Depending on the nature of the archaeological findings and available data, this layer could eventually move beyond being a supplementary feature and explicitly be included in the tool for target setting purposes.

Future Use Cases

There are a multitude of ways that the Nation can use the tool to help solve community-specific needs moving forward. At the final workshop, I outlined some potential uses to initiate further thought and discussion amongst Nation staff, the end-users of the tool. These talks centered around examining tool parameters, focusing on specific conservation features, using project outputs to better inform ongoing conservation efforts, and exploring novel conservation efforts.

One scenario that gained traction in the final workshop and merits additional exploration was to increase clustering within the tool. None of the formal scenarios run for the thesis encouraged clustering via the 'boundary length modifier' parameter, opting instead for the most efficient array of high conservation value planning units. The scattered result can be difficult to protect in practice, though. Clustered solutions provide more coherent areas that allow for more straightforward delineation and eventual protection, though they generally require a greater percentage of the landscape to meet conservation targets. This areal issue can be countered with a conservative blanket target for each feature (e.g., 40%); however, these lower targets also represent a compromise. Ultimately, clustered outputs can be more relevant and pragmatic for conservation action and should be further explored.

The Nation should also consider honing in on specific conservation features and setting targets accordingly. This could mean setting aggressive targets on a single feature or set of features, or focusing on one feature and setting conservative targets on the rest. This strategy could provide valuable insight when the Nation has conservation concerns about a specific feature or a few related features. One example is a focus on mature and old-growth forests throughout the Territory. Setting 100% targets on the mature/old forest pattern and process layers would clearly delineate these invaluable ecosystems for conservation action.

When considered in tandem, the clustered and scenario stack solutions provide the optimal catalog for identifying coherent high-value areas (Figure 5). This method could be used when scouting locations for an additional IPCA or other effective area-based conservation measures (OECMs) in the Territory. The scenario stack provides a modestly grouped solution that represents consistently selected areas across varying conservation goals. The clustered solution – based on grouping with conservative blanket targets – provides a structure of consolidated areas to choose from. Together they co-produce a pragmatic framework to facilitate delineation around consistently selected areas.

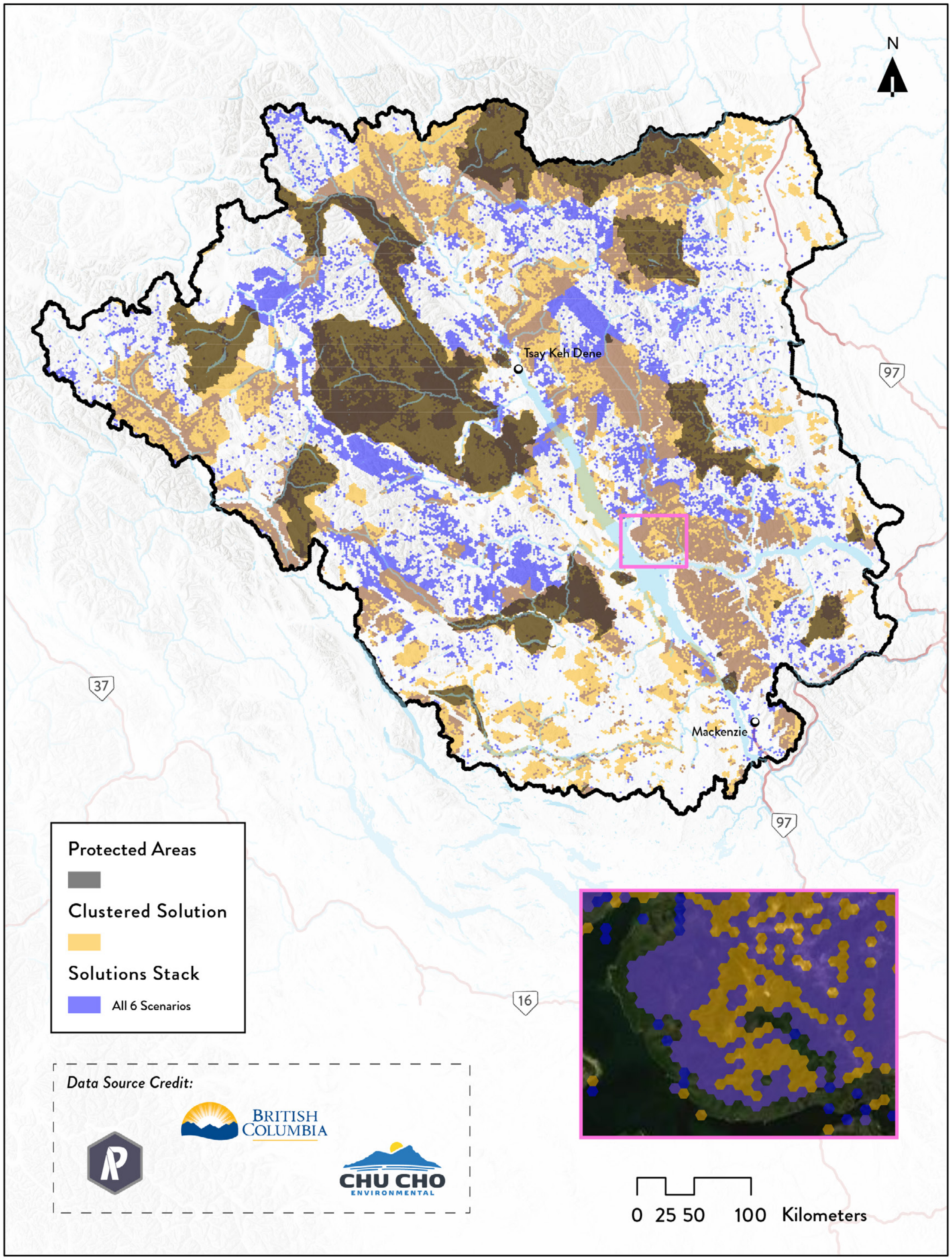

Figure 5. Spatial extent of the clustered conservation solution atop the planning units selected in all six of the thesis scenarios for the Greater Tsay Keh Dene Territory Study Area; inset represented by pink frame.

Finally, the connectivity analysis – particularly the outputs of Omnicape – should be used to inform conservation decisions. Omniscape connectivity has already proven helpful in refining the internal subunit boundaries of the Ingenika Conservation and Management Area. It could also prove useful in designing additional conservation areas – either as overall boundary delineation or strategically placing a smaller area as a potential steppingstone for movement across the landscape.

These are just a few possibilities out of the countless use cases that Nation staff can develop and ultimately apply the tool to help solve. By mixing and matching conservation features, adjusting targets, locking in different areas, and avoiding varying levels of development, the tool provides users at Chu Cho Environmental and Tsay Keh Dene Nation's Lands, Resources, and Treaty Operations office with a dynamic and agile tool to meet their conservation planning needs now and into the future.

CONCLUSION

The Tsay Keh Dene have occupied this mountain- and river-filled landscape in so-called northern British Columbia since time immemorial. They have thoughtfully managed these landscapes for millennia and continue to even in the aftermath of a devastating reservoir and continually encroaching development. This systematic conservation planning project was an effort to counter ongoing biodiversity loss using an area-based strategy that focuses on important landscape features like key species and ecosystems. I sought an outcome of inclusion and reciprocity by attempting to interweave the Traditional Ecological Knowledge of the Tsay Keh Dene throughout the process. The main goal of this work was to benefit the Tsay Keh Dene and the land they call home. At the same time, this effort benefitted immensely from the invaluable knowledge of these Indigenous land stewards and those working on their behalf.

By building a Western science-based GIS tool, Tsay Keh Dene knowledge, values, and priorities are articulated in a manner that is readily understood by the provincial and federal governments. My findings can serve to not only validate ongoing conservation efforts in the Territory but help guide future efforts by identifying additional high-value areas. These efforts will not only encourage ecological health in the Territory, but also further cultural restoration through the preservation of spiritual areas. The defensible nature of the SCP framework will help justify Nation-led conservation initiatives if and when formal negotiations take place between governments. Living in harmony with the land will always be a tenet of the Tsay Keh Dene way of life. By interweaving TEK with sound conservation science on biodiversity, climate change, and connectivity, we have developed an Indigenous-led SCP framework. This work can serve as a guide for other First Nations as a conservation planning methodology that promotes multiple ways of knowing – a strategy that is our best path forward given the urgency of the climate and biodiversity crises.

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