Wildlife VECs, Habitat Quality Models, and Species at Risk – Overview of

2) Keeyask Generation Station CEC Proceedings and Hearings

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Wildlife Habitat

As one component of standard environmental assessment, Ecostem et al. (2013) developed 'habitat quality models' in an attempt to provide understanding of the value of wildlife habitat within the area of interest, and to predict the effects of removing habitat and/or altering habitat. It is germane to pose the question "Was Keeyask Generation Project's approach consistent with some of the current scientific literature and thinking?".

We must begin by asking ourselves "What do we really mean by the word habitat? and "How does the literature define this habitat thing?". To answer the questions, I turn to the literature on bird habitat, and particularly to the 2012 book 'Birds and habitat: relationships in changing landscapes', edited by Fuller. The book provides us with the following definitions and concepts as foundation to 'habitat'.

Fuller (2012a) defines habitat as "The environment of the individual bird, including all biotic and abiotic elements.". This seems pretty straight-forward, albeit somewhat all encompassing. However, if we dig deeper, this far more to this idea of habitat.

Fuller (2012a) also provides us with a definition for 'habitat quality', that being "The fitness potential or value of a defined habitat.". OK, that is helpful if one understands the concept of fitness. Let me take a run at it. Evolution is all about getting one's genes into the gene pool, and individual fitness represents the ability of an individual of a species to achieve that goal. An individual with high fitness is one that produces lots of viable offspring that survive to become reproducing individuals, whereas an individual with low fitness is one that does not. For example, a male yellow warbler that fails to secure a mate has low fitness. Fuller (2012a) further indicated that the "processes involved in habitat selection have evolved to maximise fitness" (Fuller 2012a). On the topic of habitat quality, we are provided with two further definitions by Fuller (2012a), who stated that "Clarity about the meaning of these and other habitat-related terms is essential".

- 'Intrinsic habitat quality' is defined as "the fundamental fitness in the habitat taking no account of conspecific individuals and other species". In other words, this represents the fitness value of a habitat ignoring how members of one's own species and other species might impact on that. Intrinsic habitat quality represents the capacity of a habitat to bear on fitness via the supply of the food, shelter, nesting sites, and other requirements for a species to occupy an area.

- 'Realised habitat quality', on the other hand, "combines intrinsic habitat quality with Allee effects, competition, predation risk, etc.". This includes competition and other relevant factors within and among species, such that Fuller (2012a, 2012b) stated "these can have strong effects on realised habitat quality and use" and that "The habitat quality actually experienced by individuals, realised habitat quality, is mainly a result of interactions with other organisms, including conspecifics". Therefore, realised habitat quality incorporates the various factors, additional to resources, that influence survival and reproduction, thereby bearing on fitness within a habitat. Consider two habitats of the same intrinsic habitat quality to a species of warbler. If one habitat is used extensively by an accipiter hawk that feeds on the warbler, and the hawk rarely hunts in the second habitat, we would expect realised habitat quality to differ, all other things being equal. Figure 1 provides a conceptual model to help us understand the two types of habitat quality.

Late this summer, my better half was out picking raspberries in our garden and was stung by wasps. On investigation, there was a wasp nest in the saskatoons found adjacent to the raspberries. Over the previous days, robins and other birds had eaten all the saskatoons off the bushes. Except for where the wasp nest was, because those wasps were keeping the birds away. Those remaining saskatoons represented intrinsic habitat to the birds, i.e., food resources. However, they did not represent realised habitat because the birds could not access the berries due to the wasps.

The idea of defining habitat quality in terms of fitness is not new. For example, following their 10-year study of the highly endangered spotted owl, Franklin et al. (2000) defined habitat quality by fitness, and discussed the scientific contributions that had led to this approach. The metric used by Franklin et al. (2000) to measure habitat quality or fitness was the annual rate of population change, or lambda. Lambda incorporates the effects of both survival and reproduction. Following on this, Johnson (2007), in his review paper on habitat quality, also took the fitness perspective in defining the realised habitat quality for the individual as "the per capita contribution to population growth expected from a given habitat.". Lambda is defined as "the multiplication of the population in one interval of time" (Poole 1974), and is calculated easily as the population size at the end of an interval divided by the population size at the end of the previous interval. A number above zero indicates an increasing population, one below zero indicates a decreasing population, and a value of zero indicates that the population is stable.

So we see that lambda, which is a function of survival and reproduction, can be used to measure realised habitat quality. From this perspective, a habitat allowing high survival rates of adults and young, and for adults to produce many viable young, would allow for the relatively high contribution of individual genes and numbers to a population, and would be considered to be a high quality realised habitat. Such a habitat can also be considered to be a ‘source’ habitat; i.e., it would be a habitat that is a source of individuals in support of the maintenance of an animal population. We can contrast this with habitat that can only support low reproduction and poor survival, such that survival and reproduction are not adequate to maintain the number of individuals using the habitat. This habitat would not be considered to a high quality habitat. Such a habitat can also be considered to be a ‘sink’ habitat; i.e., a habitat that results in the loss of animals from a population. In the context of lambda, a value greater than one is synonymous with a source population, and a value less than one with a sink population.

At this time, it seems appropriate to note that Ecostem et al. (2013) defined habitat as “The place where a plant or animal lives; often related to a function such as breeding, spawning, feeding, etc.” and did not define habitat quality.

A branch of ecology known as landscape ecology has come into its own over the last three or four decades, driven in large part by the ability to handle spatial data via powerful hardware and Geographic Information Systems. Of particular importance to smaller animals, but also of relevance to larger animals, is the concept of a patchy landscape. The landscape is perceived as patches of habitat of variable quality, sizes, and shapes arranged in configurations that vary. This way of viewing habitat speaks to the greater area, and landscape ecology is rich with its own concepts. The relevance of viewing habitat at the level of the landscape can be revealed by the following example. Consider a patch of high quality realised habitat surrounded by rather hostile habitat, e.g., in terms of lack of food or a high abundance of predators. Consider that the population of the habitat patch is eliminated, for example, due to some random infrequent weather event. If the patch is far enough away from other populations such that individuals dispersing to the patch would have a very low probability of survival, the good quality patch of habitat may not again be occupied for a long time. This kind of thinking is particularly relevant to conservation biology and species at risk. For example, when an urban area is developed within a natural landscape, there are vehicles and cats and other novel things that adversely impact on the ability of amphibians and reptiles to move across the landscape, to emigrate and to immigrate. For this reason, corridors are designed with the goal to allow for the movement of animals across landscapes.

Some key aspects of landscape ecology include the following (Wiens and Van Horne 2011).

- Habitat is patchy, and “source and sink patches are embedded in heterogenous landscape mosaics, in which the details of spatial relationships are important.". The patchiness of the landscape can be illustrated using data from boreal forest in Quebec (Table 1, Dussault et al. 2006). We can see, for example, that habitat patches of ≥50 year old 'deciduous with shade-tolerant trees' had the greatest amount of browse and best food value, more browse than young deciduous or mixedwood regeneration patches, and considerably more browse, for example, than ≥30 year old 'coniferous without balsam' patches. These data simply demonstrate how, for moose, the availability of food can vary among habitats and therefore across a landscape. Considering this from the perspective of fitness, some of these habitats might contribute towards a positive lambda, while some might not (e.g., due to low volume and/or quality of the food, and an energetic cost to acquire and assimilate greater than the assimilated energy). For example, in my many miles of travel within various ecosystems in Manitoba, I have never seen moose eat speckled alder as a browse, despite it being a common and sometimes abundant species.

- Source-sink systems are not static. Change happens, and, for example, what is a sink at one time may help to support a source at another time. Consider, for example, a late spring storm that severely impacts the survival of a songbird like American warbler on its breeding grounds. Habitats that might have been sinks, as a function of inter-specific competition, may now become sources due to lower bird density and relatively great available food resources.
- Following up on the above, populations "in different parts of the landscape may have quite different dynamics" (Wiens and Van Horne 2011), and conserving populations requires an understanding of an organisms' ability to disperse.

Wiens and Van Horne (2011) summarized landscape ecology as dealing "with the effects of spatial patterns on ecological processes, and what more clearly epitomizes this than an array of habitat patches among which population dynamics differ, while the fates of populations in individual patches are influenced by the dynamics of other patches in the landscape?".

It is also germane to the idea of habitat to recognize that many species make use of a number of quite different kinds of patches. Per Fuller (2012a), for "wide-ranging species … combination of elements at the landscape scale may be important for different functions". For example, moose use conifer forests for cover and often feed in relatively open environments. Therefore, because moose relate to edges, spatial habitat models have been developed for the species.

Olive sided flycatcher

Olive-sided flycatcher is a species of bird designated as threatened by the Committee on the Status of Endangered Species in Canada (COSEWIC), and it will be impacted by Keeyask Generation Project in various ways.

The following information comes from COSEWIC's (2007) report on the status of the species in Canada. As noted in Keeyask Generation Project's EIS, the species has been little studied. Per COSEWIC (2007) and my recent literature search (Zoological Abstracts, 1992-2013), the few studies on breeding ecology were all from the western USA. There were no studies on the breeding ecology of the species for the boreal forest.

COSEWIC (2007) indicated that the olive-sided flycatcher is "most often associated with open areas containing tall trees or snags for perching. Open areas may be forest openings, forest edges near natural openings (such as rivers, muskeg, bogs or swamps) or human-made openings (such as logged areas), burned forest or open to semi-open mature forest stands. … Generally, forest habitat is either coniferous or mixed coniferous. In the boreal forest, suitable habitat is more likely to occur near wetlands.". So, per the report, the species is principally found in relatively open locations where there are the requisite tall trees or snags for foraging and nesting. Of particular importance, while habitat exists under various natural conditions, it is also found within forests that have been logged. At the basic and simplest level of consideration, both the natural habitat and the novel man-made habitat represent intrinsic habitat of some quality, as both types supply the fundamentals of required structures, food, nesting sites, and other resources.

Realised habitat, fitness, source and sink.

Let us now consider the known biology of the species from the perspective of realised habitat, fitness, and source and sink. While it appears that the species may be relatively abundant in selectively logged forest and therefore prefer such intrinsic habitat (Robertson and Hutto 2007 in COSEWIC 2007; Robertson 2012), in Robertson and Hutto's (2007) study, nest success in the logged forest habitat was only half of that in the natural burn habitat. It was suggested that the logged habitat had a greater abundance of nest predators, which were responsible for the low nest success. A finding of low nest success in logged forest was also found by Altman and Sallabanks (2000 in COSEWIC 2007). This led Robertson and Hutto (2007 in COSEWIC 2007) to conclude that the logged habitat was an ecological trap, in that such habitat would act as a sink and be unable to sustain the species. Hutton and Young (1999 in COSEWIC 2007) speculated that the olive-sided flycatcher has evolved over millenia as a species adapted to young post-fire forest, and is attracted to logged forests with similar structural characteristics. It appears that, despite the logged forest habitat adversely impacting at the level of the population and imposing fitness costs, the individual selects the novel environment because it provides attributes that natural selection over millenia has wired into the species' DNA as cues to guide selection of appropriate habitat. And while the intrinsic habitat quality of the logged forest appears comparable or superior to that of the natural habitat, the realized habitat quality is expected to be zero or near zero.

The COSEWIC (2007) report concluded that forestry development, by virtue of creating population sinks, was most likely a principle cause of the population decline of olive-sided flycatcher. Indeed, Robertson (2012), as a means to mitigate the impact of logging, proposed altered forestry practices intended to discourage the species from residing within selectively logged forest areas (Robertson 2012).

The key take home message for olive-sided flycatcher is that simply finding it at relatively high abundance during the breeding season does not make it true that the realised habitat is of high quality for the species. And that it is important to understand if a habitat is a source or sink. Another take home message is that it is likely that the high quality realised habitat of the species is subject to 'death by a thousand cuts', literally. This knowledge reinforces the notion that a 'significant' project-level effect should not be the only basis for conducting cumulative effects assessment. Clearly, altering habitat in areas where forestry development will not occur, as contemplated by the Keeyask Generation Project, is particularly relevant to a species like olive-sided flycatcher whose realised habitat across Manitoba's landscape appears to be taking a major hit due to forestry development. In a sense, the birds that will be lost due to the Keeyask Generation Project are likely to be more important than those in the logged areas, because they, unlike those breeding in the logged areas, are expected to be a positive influence on the Manitoba olive-sided flycatcher population.

The Language of Science

Science, as for other disciplines, requires that language be clear so as to enable effective communication. Ecostem et al. (2013), in its document on the Keeyask Generation Project's habitat quality models, used the terms primary habitat and secondary habitat. However, on the basis of a search through the Ecostem et al.'s (2013) and Keeyask Generation Project's (Terrestrial Environment Supporting Volume) documents and glossaries, neither party defined the terms. And, in recent review papers on bird habitat by Fuller (2012a, 2012b) and Johnson (2007), the terms were not used.

I am left to contemplate exactly what the two terms mean in relation to current scientific thinking on habitat. For example, is primary habitat synonymous with realised habitat that is a source and secondary habitat synonymous with realised habitat that is a sink? Is primary habitat intrinsic or realised?

In the absence of definitions, one can expect that different practitioners will understand and apply the terms and concepts inconsistently. For example, we might expect that someone with a strong background on mammals would be key to the construction of a beaver habitat quality model, while a bird specialist would be key to the development of avian habitat quality models. In the absence of definitions of concepts, it is not unlikely that models may be poorly comparable fundamentally.

Keeyask Generation Project's Habitat Quality Models

Ecostem et al. (2013) developed habitat quality models for six species of animals, beaver, moose, caribou, rusty blackbird, olive-sided flycatcher and **common** nighthawk, of which four are species at risk. In the interest of 'brevity', and because available time limited the breadth of my examination, I cannot address details, shortcomings, and tests of all the models. I will focus on one mammal, the beaver, and on one species at risk, the olive-sided flycatcher.

Beaver Habitat Quality Model

Within Ecostem et al. (2013), various scientific literature was cited in an attempt to provide an understanding of beaver.

The beaver builds and lives in lodges, which may be stand-alone structures of sticks and mud, or built into the bank of a creek or river. The species selects lodge locations on the basis of various criteria. For example, along the floodplain forest of the Big Sioux River in South Dakota, Dieter and McCabe (1989) found the slope of the riverbank and water depth to be important physical characteristics influencing selection, where beaver built almost exclusively within the riverbank. While these findings may not be directly transferable to the ecosystems under consideration in this deliberation, the point is that a number of factors can influence the location of a beaver lodge.

Food Resources

Studies of food habits have focused almost entirely on the woody component of the beaver's diet, i.e., twigs and bark. This is almost certainly so because beaver typically build an obvious winter food cache composed primarily of shrubs and parts of trees, and because we can easily observe where beaver have cut shrubs, such as a willow, or trees, such as a trembling aspen. Respecting studies of diet based on shrubs or trees that have been cut, we must be careful when interpreting the information. For example, speckled alder tolerates wet areas and is often found near water, and at times beaver cut the species. However, anti-nutritive compounds severely limits the ability of beaver to digest speckled alder. When fed a diet exclusively of speckled alder, the alder moves very slowly through the beaver's gut such that this diet is unlikely to support the energetic cost of existence. For example, Fryxell et al. (1994) found that, of five plant species fed to beaver, the rate of feeding on leaves, twigs, and bark (kg/day) was lowest and the retention time in the gut greatest, for speckled alder. This led them to conclude that "beavers feeding on monospecific stands of alder were barely able to meet their energetic demand". Of note, woody vegetation stored in the cache appear to be poorly digestible (Buech 1987). Therefore, we must be cautious in assessing diet on the basis of shrubs and trees that a beaver has cut. It is my expectation that speckled alder is used exclusively for building (e.g., lodges, dams), or possibly as a very minor component of the diet to provide protein and/or micronutrients. Similarly, we must be cautious respecting shrubs and trees, as they are also used for building, albeit often as the remnant of the beaver eating the bark from the trees.

Beaver food supply and preferences

It has long been known that beaver also feed on aquatic plants, such as cattail and pond lilies, but the relative importance of such food, particularly in winter, has been poorly understood. However, **in Manitoba at least**, we have understood that aquatic plants could play a very important role in the winter survival of beaver. For example, for the boreal forest of southeastern Manitoba, MacArthur and Dyck (1990) provided evidence to suggest that beaver will forage on emergent vegetation under the ice, presumably where they can feed on the rhizomes of species like cattail (*Typha spp.*) that are likely high in digestible energy (Campbell and MacArthur 1994). MacArthur and Dyck (1990) documented under-ice excursions of up to 42 minutes, far exceeding the known diving endurance of beaver, and suggested that the beaver were using air pockets below the ice. In northern Manitoba, Nash (1951) indicated that the rhizomes of pond-lily were commonly found in caches, and could constitute a major food item for beaver. In the USA, Jenkins (1981) reported that the rate of tree cutting during fall was minimal for a colony with access to pond-lily rhizomes. My examination of the body composition of beaver, mostly from Manitoba's Cooks Creek and Netley Marsh (Soprovich 1995), led me to conclude that beaver were able to put on fat under the ice and to maintain body condition, in terms of fat resources, over the winter (Figure 2). In my study, beaver appeared to rapidly use up their fat resources around the time of spring breakup. On the basis of an understanding of the value of various food resources, and the energetic needs of beaver (Dyck and MacArthur 1993a), I postulated that the woody component of caches would not suffice for winter energy needs of beaver. And further that aquatic plants, particularly the energy rich tubers of species like pond-lilies, could be an important component of a beaver's winter diet. Soprovich (1995) suggested "that such food items should constitute a highly preferred forage of beaver during the winter". In summary, the evidence simply did not support the notion that beaver would be able to maintain body condition over winter solely on a diet of shrubs and the bark of trees.

In a more recent time, stable isotope analysis has provided an opportunity to estimate the importance of various dietary components over the annual cycle of the beaver. And in a recent study in Voyageurs National Park in Minnesota, the importance of aquatic plants in the diet of beaver was highlighted (Severud et al. 2013). For their area, these researchers estimated that, over the course of a year, aquatic plants represented more than half (55.5%) of a beaver's diet. During the winter when beaver were generally restricted to movement below the ice, aquatic vegetation was used to the same extent as in summer (55.2% vs 56.1%, respectively). However, pond-lilies, like the small yellow pond-lily found in the Keeyask Study Area (Appendix H-4; Ecostem et al. (2013)), represented a greater portion of the winter diet in comparison to emergent food, such as cattail. Clearly, this most recent line of evidence strongly supports the evidence conclusions of Soprovich (1995) respecting the value and importance of aquatics in the beaver winter diet.

Several other considerations are important to the use and selection of aquatic vegetation versus that of terrestrial woody vegetation. Several species of large mammals, and in particular wolves, kill beaver during times when beaver are not ice-bound. Beaver are relatively slow and somewhat unwieldy out of water, and are not well adapted to escaping large predators. Consequently, the risk of being predated is believed to be relatively great when beaver are cutting shrubs and trees on land, and to increase as a beaver moves further away from the water. Energetic costs, which may also be relatively high at times on land, are another consideration.

Background for the Habitat Quality Model

Examination of Ecostem et al.'s (2013) report entitled 'Habitat Relationships and Wildlife Habitat Quality Models' led me to the following observations respecting Keeyask's beaver habitat quality model.

- Ecostem et al. (2013) stated that beaver "manage to harvest a sufficient number of trees to maintain their energy requirements." (Page 6-1). However, they do not provide evidence in support of the statement, and clearly, based on current literature and Manitoba literature from Nash (1951) and the 1990's, the statement is without foundation and simply wrong. Beaver do not rely exclusively on trees to meet their energy needs, have been shown to forage to a greater extent on aquatic vegetation, and it is entirely possible that the trees primarily fulfill a winter protein requirement as opposed to an energy requirement.
- On page 6-3, Ecostem et al. (2013) stated that "Beaver tend to shift from a woody diet in winter to an herbaceous diet in spring and summer (Jenkins and Busher 1979; Clements 1991)". This statement is clearly questionable given the recent evidence of Severud et al. (2013).
- Ecostem et al. (2013) stated that "the leaves and growing tips of willow, poplar and alder (Baker and Hill 2003) … are generally consumed.". I do not believe the statement to be true relative to speckled alder, which is the alder species of particular relevance to the discussion. And evidence from feeding trials does not support the statement (e.g., Fryxell et al. 1994). I have read and believe Slough (1978), and agree with Ecostem et al.'s (2013) statement that "Beaver have also been observed using alder as structural material instead of food (Slough 1978).". I suspect that Ecostem et al. (2013) likely misunderstood the language and/or the science behind the first citation. I.e., Baker and Hill (2003) is a review document, and if those authors referenced

the use of alder as foot, the science may have been based solely on beaver cuttings. Further to this, relative to the cache, Ecostem et al. (2013) stated "Alder raft/cap freezes into ice with primarily aspen and willow stored under …". One must question why, if alder were a preferred winter forage, beaver would preferentially cap a cache with alder where it will soon freeze, as opposed to incorporating it in a significant amount within that part of the cache less prone to freezing.

- Ecostem et al. (2013) stated that "Winter food preferences include bark from trembling aspen, poplar, willow, birch, cottonwood, and alder; additional summer food sources include sedges, grasses, as well as water lily and cattail roots and stems.". The statement is clearly wrong respecting speckled alder, and respecting the inference that aquatics are not used or important during the winter.
- Table H-4 lists the value of various food plants to beaver according to Ecostem et al. (2013).
    - Speckled alder is rated at two out of three, with three being of greatest value. Yet, in my view, this species would be eaten minimally, if at all. I would expect green alder to be eaten given the opportunity, as I have seen the species at times used extensively by moose in the ecosystems of the Duck and Porcupine Mountains, where moose do not eat the widespread and abundant speckled alder.
    - Relative to aquatic plants, Soprovich (1995) suggested that beaver might eat sedges and Severud et al. (2013) included sedges as a forage species. This group of plants would be within the Keeyask Generation Project area but is not on the list.
    - Of the 16 species of terrestrial plants, 2 were rated at three, 13 rated at two, and 1 at rated one. Of the 8 species of aquatic plants, 1 was rated at two and 7 were rated at one. Clearly, based on Severud et al. (2013) and the evidence from Manitoba, these ratings are incorrect and, solely from the perspective of energy resources, likely the opposite of what is true. These incorrect ratings are likely the result of Ecostem et al. (2013) not having a full grasp of the relevant literature, and failing to understand the limitations of the literature that it did examine. For example, failing to understand that simply because a shrub is cut, this does not mean that it is eaten.
- Ecostem et al. (2013) stated that "Energy deficits require energy conservation methods such as reduced activity and periods of dormancy (Novakowski 1966).". This speculation may have been true relative to reduced activity for Novakowski's study area, and appears to occur to some extent in beaver in the boreal forest of southeastern Manitoba (Dyck and MacArthur 1992). With respect to 'dormancy', beaver do not appear to depress their metabolic rate to conserve energy (Smith et al. 1991, Dyck and MacArthur 1992). Importantly, there is much more to this story. If one understands the limitations of the Novakowski thesis, and has the barest understanding of beaver biology, the data clearly point to the need for beaver to supplement their winter diet with food outside of the cache. This is because Novakowski (1967) assumed

digestibility rates that were almost certainly too high, and because he also massively overestimated the energy resources of the cache, because he included the energy of the woody parts of the trees. Beaver eat the bark of the trees, and would essentially ignore the woody part because it is composed mostly of cellolose that is very poorly digestible. Novakowski (1967) also ignored the potentially high metabolic costs of digestion and foraging in cold water (Dyck and MacArthur 1993a). In summary, after consideration of the various lines of evidence, the energy resources of a cache are not expected to be adequate for the needs of beaver over the winter, and the shortfall may be substantial.

- "Winter temperatures restrict beaver movement to below-ice activity (Mueller-Schwarze 2011)." and "Above-ice activity occurs when daily air temperatures are above –10C (Lancia et al. 1982).". The suggestion that beaver are restricted to below the ice is highly questionable. The energetic cost of being in cold water considerably exceeds that of being in air (MacArthur and Dyck 1990). Further, for an Arctic population of beaver, as many as half of the colonies cut holes in the ice and emerged to forage one month prior to break-up (Aleksiuk 1970). It is also relevant to understand that Lancia et al.'s (1982) study was of two beaver colonies in Massachusetts, USA, and that Mueller-Schwarze (2011) is a book, i.e., not primary literature.
- "Lodges and burrows help create a microclimate that maintain a temperature of approximately 0C, allow beaver to live in extreme northenn climates (Lancia et al. 1982).". Again, Lancia et al. (1982) studied 2 beaver lodges in Massachusetts. Lodge temperatures from 14 occupied lodges in the boreal forest of southeastern Manitoba averaged approximately 10 C or warmer from November to March (Dyck and MacArthur 1993b).
- "In winter, beaver tend not to travel beyond their food cache; home ranges are generally 0.25 ha in size (Wheatley 1997b).". Beaver clearly can, and do, travel beyond their food cache, as evidenced by MacArthur and Dyck (1990). Furthermore, where air pockets are common beneath the ice, beaver may be able to travel extensively.
- Some of the problems with Ecostem et al.'s (2013) Figure 6.2, "Linkage Diagram of All Potential Effects of the Keeyask Generating Project on the Beaver Populations", are as follows.
  - Winter food, other than woody terrestrial vegetation, was ignored for 'Winter Food Storage', when we know that aquatics are important in winter.
  - Disease & Accidents are suggested to be of very low importance. In fact, population crashes attributed to tuleremia have occurred in Manitoba. Clearly, there is some history of disease being quite important at times.
- Some of the problems with Ecostem et al.'s (2013) Table 6-1, 'Beaver Life Requisites and Factors that Can Substantially Influence Survival, Reproduction, and Habitat Use', are as follows.
  - The importance of aquatics was ignored as winter food, rather, winter food was suggested to be "Woody diet – bark" (i.e., deciduous trees and shrubs).

- Beaver were indicated to “Require 1.5 lbs of food (bark/twigs) daily” during the winter. This ignores the importance of aquatics.
- During “summer through fall”, it was indicated that beaver eat “Alder … growing tips”. The species of alder is not supplied in the Table. However, I strongly suspect that this would relate to speckled alder being cut for a building material. Similarly, beaver was indicated to eat “alder bark” during the spring. This is highly questionable.
- Respecting “Predators and avoidance”, it was indicated that this occurred “Year round” and that “Humans, wolves, coyotes, bears, lynx and wolverines” were the culprits. To be clear, species like wolves and bears typically do not predate on beaver when they are below the ice and, for example, bear are in hibernation. I personally would not include humans with the other species, as humans would not be subject to the same type of predator-prey relationships. Finally, otter are known to prey on beaver, and that species is missing from the list.
- Respecting “Diseases/Parasites”, it was indicated that “Tick or deerfly bite” was one vector for the transmission of tularemia in Manitoba. Of relevance to this, ticks do not occur within the Keeyask Generation Project area.
- Of importance, the Table included numbers that presumably were to relate to literature, but there was no link between the number and anything. Consequently, it was impossible to fully evaluate the Table.

OK, no need to ‘beat this to death’ anymore, the reader should ‘get the picture’.

The Beaver Habitat Quality Model

Ecostem et al. (2013) provides an understanding of Keeyask’s beaver habitat quality model via the statement that “Beaver require suitable amounts of poplar, alder, and willow of certain size to provide a sufficient food supply and as building materials.”. Consequently, other than the ‘Marsh’ coarse habitat type, it appears that Ecostem et al. (2013) only considered ecosystems that provide woody vegetation to be beaver habitat. The model addresses the woody component of the beaver diet, but effectively ignores the aquatic component.

What is primary habitat and what is secondary habitat? While not defined in Ecostem et al.’s (2013) glossary, these terms were defined implicitly in the text as follows.

- Primary habitat. “Coarse habitat types were assigned importance as … either meeting all food requirements, or valued as less suitable where there appeared to be some deficiency (i.e., missing plant species, containing less preferable plant species, or limited abundance).”.
- And then “Secondary coarse habitat types were selected if they provided additional sources of less desirable and potentially less abundant browse, or as a secondary source of lodge building materials.”. It is important to note that the building and maintenance of lodges requires little material, and that

this material is often a byproduct of the logs remaining in the spring from the winter cache. I would expect building materials for lodges to never be limiting for beaver. Dams might be another matter.

What does primary habitat and secondary habitat really mean? Primary and secondary perhaps connotes some little difference in value and/or quality, but this is not clear. For example, thinking in terms of fitness, would we expect beaver using secondary habitat to exhibit lower reproductive rates, or lower survival as they might have to forage further afield? Would the secondary habitat be ‘sink’ habitat where young dispersing beaver go to die? Just how do these two habitat types sort out in terms of intrinsic habitat, realised habitat, fitness, and source and sink perspectives? That is, what does Ecostem et al. (2013) and Keeyask really mean when they use the term ‘habitat’. Without a clear definition, I cannot be certain, but my view would be that these coarse habitat types are likely to be intrinsic habitat. I have not examined the plant composition of the various coarse habitat types, and I have not conducted reconnaissance of the Keeyask Generation Project area. However, I expect that at least some of these types would generally not be considered to provide realised habitat for beaver, including most of the secondary habitat types, as the food quality and/or quantity would likely not satisfy minimum needs. Food quality is likely to be as important or moreso than quantity. While a coarse habitat type having only speckled alder would have lots of food per Ecostem et al.’s (2013) model, if quality were considered, it would have no food per the experimental feeding tests.

Beaver habitat was considered to occur “no farther than 200 m surrounding a creek” and within “upland habitats” located no farther than 100 m from a lake or pond shoreline (Page 6-22). It is unclear what the basis was for this creek/pond and lake dichotomy. For example, what was the basis for the use of 200 m for creeks? The dichotomy may have been an error, as later, within the sections on validation and application of the model, a distinction was not made (i.e., Pages 6-23 and 6-24).

In summary, given that aquatic plants may often represent a significant component of the diet of beaver, and offer a high source of energy during the winter, it seems incredible that one would effectively ignore the aquatic habitat when attempting to construct a habitat model for the semi-aquatic species. And while there may or may not be data in support of this, I would strongly expect that the availability of aquatic food resources would generally be a criterion of high importance for the selection of a location for a lodge and for ongoing use of that location.

The ‘Test’ of the Beaver Habitat Quality Model

Under conditions of effectively ignoring potentially half or more of the food of beaver, and other factors that could influence lodge selection, should we expect Keeyask’s beaver habitat quality model to be valid? Without looking at Ecostem et al.’s (2013) tests, and given this knowledge, the objective observer might expect there to be a high likelihood that the model would not pass muster. Let us see.

As best as I can tell, Ecostem et al.'s (2013) test of its model involved using a GIS to construct circles (buffers) of variable radius around active and inactive lodges, and determining the various coarse habitat types found within the circles as an indication of the habitat being selected for by beaver. Plant communities within 100 m of shoreline were considered to provide beaver habitat. This suggests that the earlier referenced creek/pond and lake dichotomy was an error, because if it was not, lodges at creeks likely should have been considered separate from those at ponds and lakes.

Ecostem et al.'s (2013) approach to lump the active and inactive lodges together in a validation exercise seems, for lack of a better term, silly. First and foremost, there were reasons why these lodges were abandoned. For example, perhaps disease killed all of the residents. However, thinking as a scientist, it is reasonable to consider and hypothesize that most of the lodges were abandoned because the realised habitat quality was inadequate. And if true, then it would not be appropriate to lump active and inactive lodges together to test a habitat model. Indeed, comparing habitat, terrestrial and aquatic, for active versus inactive lodges might provide insight into source and sink habitats, and fitness. Secondly, a scientific approach would test for differences between active and inactive lodges as a first step in analysis of the data, and lump or not lump accordingly. A scientific approach does not simply assume that differences do not exist and that it is appropriate to lump groups; rather, one is led by the data. A scientist might ask also questions like "Did the abandoned lodges have a greater proportion of primary habitat than the active lodges?", which if true, would be opposite to what would be predicted if the model were true. Finally, it is important to note that only 53.3% of the lodges in the sample were active.

Of further importance to the test, Keeyask's habitat quality model appears to reflect intrinsic habitat, whereas field data may represent realised habitat quality. For example, if one is a beaver, then building a lodge close to a wolf den may be a poor choice, irrespective of how much aspen is found at the site. Given this, it seems likely that model and test are mismatched.

There are technical and scientific problems with Ecostem et al.'s (2013) use of buffers to assess habitat selection for a semi-aquatic species like beaver, as follows.

- In defining "selected" habitat for its test, Ecostem et al. (2013) included the most abundant coarse habitat types that cumulatively represented 80% of the area of the circles (Page 6-20). Photo 6-1 shows a beaver lodge in the area of interest. There is a narrow band of coniferous trees in the vicinity of the shoreline, with valued deciduous trees behind the conifers. One cannot be certain respecting the distances, but if one were to apply a 100 m buffer to this lodge, it is entirely possible and perhaps probable that the deciduous trees might not be included within the buffer. It is almost certain that this terrestrial habitat of high value would not have been included within the cumulative 80% of the buffer that Ecostem et al. (2013) treated as selected for by beaver. In this case at this scale, the most important habitat, in terms of terrestrial resources, would have been disregarded as a function of poor test methodology. Clearly, for the semi-aquatic beaver, the aquatic component of its habitat should have been treated independently of the terrestrial component. The buffering approach used by Ecostem et al. (2013) has been applied to terrestrial species, in trying to determine if selection occurs at different scales. It appears that Ecostem et al. (2013) took a cookie cutter approach and applied the method without thinking about whether it was appropriate for a semi-aquatic furbearer.

Photo 6-1. "Beaver Lodge in Northern Manitoba" from Ecostem et al.(2013)

- Consider that, other than 'Marsh', this test was supposed to be about the quality of habitat in terms of the provision of woody vegetation (Table 6-7), yet the test method was to use a circle that could include a considerable amount of aquatic habitat between a lodge and land. And presumably this amount of water would vary considerably among beaver lodges, dependent on the distance between the lodges and land. Why would one test in this manner as a means to examine the selection of woody vegetation?

In the test of its habitat quality model, Ecostem et al. (2013) considered coarse habitat types within 100 m of the shoreline. The inconvenient truth is that Stoffyn-Egli (2011), on the basis of review of the scientific literature, indicated that 95% of the terrestrial woody plants cut by beaver are within 50 m of the water's edge. Because large mammals such as wolves and bear predate on beaver, and likely for other reasons such as energetic cost-benefit, beaver do not venture too far from the water's edge to cut shrubs and trees. The research summary by Stoffyn-Egli (2011) suggests that the realised habitat quality of plant communities beyond 50 m is zero or very close to zero. In effect, what Ecostem et al. (2013) have done is to ascribe the same value to coarse habitat types found within 10 m of the shoreline as those found, for example, 99 m from the shoreline. Given that it is the first 50 m of coarse habitat types that is important, considering coarse habitat types beyond 50 m is not appropriate, and can only serve to mask, or hide, reality. This is a fatal flaw respecting Ecostem et al.'s (2013) test of the model. And when one does not fit the scale of one's test to the known biology of the animal, one should not be surprised if the model fails the test.

The method used to test habitat association does not do so. Per Fuller (2012a), habitat association is "The extent to which an individual or a population depends upon, or shows disproportionate use or avoidance of, a defined habitat type. Can be positive, neutral or negative.". Simply put, for one to address this concept, one needs to relate the habitat that is used per one's data to the habitat that is available for use. Ecostem et al. (2013) did not do so, as the following demonstrates.

- Ecostem et al. (2013) stated "Of the 139 beaver lodges examined, only 28 (20%) were directly on areas identified as primary habitat.". In terms of habitat association, this is a meaningless statement in the absence of information on the relative abundance of primary habitat in the context of a defined sampled landscape. First we would have to know where the test area was, then we would have to know the amounts of each coarse habitat type within the test area, then we would have to compare those near beaver lodges to those within the test area, and then, incorporating some assumptions, we might make some conclusions about habitat association. Of coarse, this ignores the fundamental problem of Ecostem et al.'s (2013) use of an inappropriate test scale.
- Ecostem et al. (2012) stated "Tall shrub on riparian peatland was predicted correctly, and ranked fifth.". It is unclear what this statement means, e.g., in terms of "predicted correctly", and there is no evidence to support the statement. Disregarding the strange test methodology, I would conclude, looking at the data in Table 6-8, exactly the opposite. That is, 'Tall shrub on riparian wetland', a 'primary habitat' per the model, ranks behind three 'secondary habitats' and ahead of four. The evidence suggests no difference between the 'Tall shrub on riparian wetland' primary habitat and secondary habitats. The separation predicted by the model is not illustrated by the data, again ignoring the strange methodology. Given the high value of the broad-leaved forest type, for example, with the only two 'three-star' food species, why are those coarse habitat types missing from the Table? What of the other 'primary' habitat types? I would expect that the strange test methodology may have had a bearing.

Ecostem et al. (2013) concluded with the statement that "Adjustments to the model were not made.", although, for 'primary' habitat, they did change 'Marsh' to 'Off-system marsh' and they also continued to include 'Nelson River shrub' when, in their text, they indicated that "the Nelson River (including Gull Lake) and the main body of Stephens Lake were excluded as beaver habitat.".

Ecostem et al. (2013) indicated that, respecting their test of the model (Table 6-8), it was not of concern that beaver lodges did not positively associate with the coarse habitat types identified as 'primary' habitat, which purportedly had all of a beaver's needed food. That is, "Of the 139 beaver lodges examined, only 28 (20%) were directly on areas identified as primary habitat. This is not surprising as the most-preferred habitat (i.e., broad-leafed forest) is relatively rare in distribution and extent compared to all other forest types.". Firstly, the statement suggests that there are different classes of 'primary' habitat, when everywhere else the 'broad-leafed forest' dichotomy is not made. Respecting the observation of a low percentage of lodges being found somewhere near primary habitat (i.e., "directly on areas", whatever that means), I note 1,301 ha of primary habitat within the Keeyask Regional Study Area (Table 6-10). This is the equivalent of more than 130 linear km, which seems substantive at face value. Clearly, the failure to demonstrate positive association represents a failure of the model and I strongly disagree with Ecostem et al.'s (2013) conclusions. I strongly believe that their means of testing the model was fatally flawed, and likely had a substantive bearing on failure of the model. The test of 'validation' itself was not a valid test.

One must also believe that the use of abandoned lodges in the test had a bearing. Finally, Ecostem et al.'s (2013) lack of understanding of the criteria that beaver are likely to use generally, and in the area of interest, to locate a lodge and remain viable within a site is also fundamental to the failure. For example, the relative importance of aquatic plants vs terrestrial plants to beaver. Is the model even relevant if beaver do not associate with the supposed best habitat in the area? Ecostem et al. (2013) defined validation as an evaluation of "how well the model performs relative to its intended use". My presumption has been that the intended use was to **accurately** predict habitat quality. But perhaps I am wrong respecting the intended use, because Ecostem et al.'s (2013) validation test provided no evidence in support of their beaver habitat quality model. What is the point of doing these tests of models if, despite failure, they lead to no adjustment to models? Why put in the time and effort, and cost? Unless it is to simply tick off some 'Environmental Assessment' box in a regulatory environment lacking scientific standards.

Species at Risk – Surveys and Methods

Standard practice dictates that environmental assessment address the implications of a development on species at risk. As baseline for the purpose of doing so, one typically collects data in habitats in the area to be disturbed because, among other reasons, existing scientific literature and understanding may not well apply to a species use of perhaps novel environments in unstudied or poorly studied ecosystems. Keeyask Generation Project collected data on four species of at-risk birds in the area to be disturbed, and it is relevant to pose the question "Does the collected data support Keeyask Generation Project's ability to appropriately value the importance of the areas of interest to the species at risk?".

The typical goal for any given method of survey is to produce some measure or index of abundance that relates reasonably well to the true abundance of a species. Survey methods for birds vary in relation to a number of factors. Considerations relate to, for example, whether a bird is relatively easy to observe during its breeding season, like a duck, versus if it is difficult to observe, in which case one might listen for it to sing or call. Consequently, we observe in Keeyask Generation Project's assessment the use of a standard songbird breeding bird methdology for the olive-sided flycatcher and a very different survey method using remote recording equipment for common nighthawk and yellow rail. For relatively rare wide-ranging species like owls, the use of radiotransmitters is an important means to understand habitat use. The bottom line is that, in attempting to understand habitat needs, the method has to be appropriate for the species.

In practical application in the real world, many variables can impact on the comparability of data from a given method. For example, individuals vary in their ability to see birds, or to hear and identify calls and songs, and this ability can change with time. Weather conditions may impact on one's ability to hear a bird, influence bird behaviour, or result in glare off the water during waterfowl surveys. Turbulent and other flying conditions can also cause those who do not fly well to fill sick bags or to fall asleep after taking drugs. I clearly remember a highly respected and experienced songbird surveyor telling me that on one project the contractor was using inexperienced people who were misidentifying species, and that 25% of the plots that were supposed to be in aspen forest were actually in beaver ponds and other areas. These are just a few of the things that happen out there in the real world of conducting animal surveys.

One tries to control for these kinds of effects via the application of rigorous standards. However, in the real world, there are schedules and deadlines to be met, and there are practitioners who are quite prepared to compromise to 'get the job done'. So in particular, survey standards are likely to be compromised when assessments and schedules are rushed. For example, when songbird surveys are scheduled at the last moment, this is one of the times where the warm inexperienced body will be used by some consulting firms, with the concurrent impact on the quality of the data. This is just one of the reasons why recording devices have been used for songbird surveys in recent history.

At the end of the day, each survey method has its own unique challenges, and there are imitations in terms of what the objective and critical practitioner one can reasonably infer from the data.

Finally, survey methods can evolve over time, and this may render direct comparison impossible because the nature and magnitude of biases differ among methods. Around the 1970's, the Canadian Wildlife Service conducted fall staging surveys for ducks in Manitoba, using observers in an aircraft to count the birds. However, after a critical analysis, the data resulting from the method were found to be unreliable and the surveys were ceased.

Keeyask Generation Project's Survey Method for the Olive-Sided Flycatcher

As earlier noted, the habitat of the olive-sided flycatcher is principally "open areas containing tall trees or snags for perching. Open areas may be forest openings, forest edges near natural openings (such as rivers, muskeg, bogs or swamps) or human-made openings (such as logged areas), burned forest or open to semi-open mature forest stands." and "In the boreal forest, suitable habitat is more likely to occur near wetlands." (COSEWIC 2007). Importantly, edge appears to be an important element of most or possibly all of these habitats. Although not providing evidence to support its statement, it its draft document Keeyask Generation Project's consultants (Ecostem et al. 2013) indicated that "the majority of olive-sided flycatchers observed during field studies occurred in areas supporting mature black spruce forest adjacent to beaver floods, creeks, lakes and regenerating forest (i.e., burns).". The importance of edge was reinforced by Keeyask Generation Project's definitions of primary and secondary habitats, i.e., per Table 6B-8 (Terrestrial Environment. Section 6: Birds).

- Primary habitat. Forests "within 50m of an edge … beaver ponds with snags; water; bogs; muskegs; open areas with snags and lakes with standing dead trees. Or adjacent to poor wooded fen, rich wooded fen and wooded swamp.".
- Secondary habitat. "Young needle forest/woodland (spruce dominated) or late successional open and semi-open coniferous and or mixedwood forests within 50 m of an edge". One note, "late successional open and semi-open coniferous and or mixedwood forests" was indicated to be both primary and secondary habitat within this table, so there is some kind of error in the Table.
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Edge Effects – Soft and Hard

Of relevance, while Ecostem et al. (2013) do not define edge, it is implicit within their definition of edge effects as "an abrupt transition between two different adjoining ecological communities". Their definition appears to be synonymous with what has been called a 'hard edge', as opposed to a 'soft edge'.

Excepting burns, forest openings, and 'open to semi-open mature forest stands', this statement suggests that habitat use by the species within the Regional Study Area was similar to that reported within the scientific literature.

Avian count methods

In recent practice, fixed radius circular point count plots and limitless point count plots have been a, if not the, primary method used to derive indices to songbird abundance. In the fixed radius plot, one counts the detections within a fixed distance from the centre of the plot, say 50 m or 100 m. Of course, one's ability to hear a call or song varies with distance, and some birds are quiet while others are loud. This has led researchers to try to determine at what distance the various species can be heard. For example, in a test by Schieck (1997), 27% of broadcast vocalizations were missed at 100 m from the speaker, detection varied in relation to the age and type of forest, and a number of other factors such as the frequency and height of the vocalization.

This led him to recommend that, for distances beyond 50 m in forest habitats, "comparisons among forest types should be interpreted cautiously unless the researchers demonstrate that biased detection of vocalizations did not affect their conclusions.". At a practical level, there may be tradeoff between being able to hear all of the birds and trying to survey a reasonable amount of area. However, the objective and critical practitioner always examines the potential for bias and impacts to data comparability as possible. I note here that the Keeyask Generation Project assessment made use of 75-m radius plots.

More recently, Simons et al. (2009), in their paper 'Sources of measurement error, misclassification error, and bias in auditory avian point count data', wrote that "despite the substantial time, effort, and money expended counting birds in ecological research and monitoring, the validity of common survey methods remains largely untested." and "Most practitioners assume that … observer training obviates the need to account for measurement and misclassification errors in point count data.". Recognizing the problem of the variable ability of observers to first detect, and then correctly identify, bird songs and calls, there has been some move towards using recording devices to standardize this source of bias.

Finally, Simons et al. (2009) indicated that "factors affecting detection probabilities on auditory counts, such as ambient noise, can cause substantial biases in count data. Distance sampling data are subject to substantial measurement error due to the difficulty of estimating the distance to a sound source when visual cues are lacking. Misclassification errors are also inherent in time of detection methods due to the difficulty of accurately identifying and localizing sounds during a count.". And that these important factors were "often ignored components of the uncertainty associated with point-count-based abundance estimates.".

Birds in Terrestrial Volume of EIS

Keeyask Generation Project (Page 6A-2, Terrestrial Environment. Section 6: Birds), in its document, indicates that terrestrial "breeding-bird surveys were consistent with standard procedures and included using the point count method". Unfortunately, appropriate detail is often lacking within the document. For example, within the methodology section, the Keeyask Generation Project document does not indicate that plots of fixed-radius 75 m were used.

Of particular importance, over the last number of decades, a 'standard procedure' has often been to locate plots some 50 or 100 m from edges. That is, away from where one type of habitat changes to another. For example, Hobson and Schieck (1999) indicated that "Where possible, the outer edges of the strip transects were ≥100 m from adjacent forest types.". Due to their shapes, "1-32% (mean 8%) of the outer edge of the transect was 50-100 m from adjacent forest types" for nine of the 18 stands (and see). The thinking has been that, as a first approximation/understanding of songbird habitat use, data collected near edges would obscure species' relationships with the relatively homogenous core habitat, because species would likely mix near the edges. Since being introduced to this method sometime in the 1970's, I have often wondered about the extent to which this has restricted our understanding of birds. As a quantitative person who at times analyzes data, I recognize the practice as resulting in likely significant portions of study areas being unavailable for sampling, and therefore not part of what we call the statistical universe. To the point, Fuller (2012b) stated “Restricting sampling to part of any environmental gradient can give an incomplete representation of habitat association.”.

Sampling away from edges

I have been unable to determine if Keeyask Generation Project and its consultants attempted to constrain sampling to some distance from edges, as Keeyask Generation Project (Terrestrial Environment. Section 6: Birds) and Ecostem et al. (2013) in its draft document are silent in this regard. Consequently, my first thought was that Keeyask Generation Project did sample away from edges, as this could be considered ‘standard practice’. Further to this, various lines of evidence suggest that this was the case. For example, Table 7-1 of Ecostem et al. (2013) does not include edge habitat types (i.e., if a plot had two or more habitat types, then the Table should have indicated it to be a distinct ‘mixed’ type). Similarly, if a bird had been observed in a plot that contained a mix of habitat types, it would have been appropriate to indicate such, but this was not done in Table 7-4 of Ecostem et al. (2013) or in TetrES (2004).

At the same time, TetrES (2004) makes conflicting statements like “transects were located within relatively homogenous habitat” and “The habitat use of each bird relative to habitat edges was also recorded (e.g., water, edge, or forest interior etc.).”, while Keeyask Generation Project indicates that “final selections” were “within habitats that were as homogenous as possible”. Importantly, the habitat types used at the time of the 2001 TetrES (2004) survey are radically different from those used in Ecostem et al. (2013). And therefore it seems impossible that these early plots would all fit neatly within Ecostem et al.’s (2013) broad habitat types. So we have confusion and uncertainty about exactly what it is that Ecostem et al.. (2013) have done. Compounding the confusion is the footnote to Table 7-2 that stated “In cases where several broad habitat types occurred within a point count, the broad habitat type of the stand that covered the majority of the 75-m point-count radius was used.”. So it is apparent, not surprisingly, that at least some of the plots incorporated multiple broad habitat types. Immediate questions come to mind in relation to the frequency of occurrence, and the types and relative contributions of the broad habitat types for mixed group plots.

It seems fair to assume that, though not explicit, there was an attempt to locate plots in “relatively homogenous habitat” (TetrES 2004) and away from edges to mitigate edge effects. What we do not know is the extent to which this occurred. For example, was it typically 50 m or 100 m or what distance? What was the average? And where did this occur (i.e., what kinds of edges)?

Relevance to olive-sided flycatcher

Now the relevance of this to olive-sided flycatcher is as follows. Let us assume that the species relates strongly to edge, as indicated by the scientific literature.

If all of Keeyask Generation Project's sample plots were located, for example, 100 m away from habitat edges, then the sampling design would be quite inappropriate for olive-sided flycatcher. The survey would not match the species biology. And given an inappropriate design, I think it quite reasonable to anticipate that the resulting data would undervalue, perhaps significantly so, the overall importance of the area to the species, in terms of abundance. If one does not look in the right places, one should not be surprised if one does not find. I do note that I have seen nothing in Keeyask Generation Project (Terrestrial Environment. Section 6: Birds) or Ecostem et al. (2013) respecting how appropriate the sampling design was for olive-sided flycatcher as an 'edge' species.

Audit the data

Given the lack of information in Keeyask Generation Project materials, there is only one means by which the objective and critical practitioner can evaluate the significance of this matter, and that is to audit the raw data. It is not uncommon that one can only truly understand what someone has done by looking at the raw data. If it was me auditing Keeyask Generation Project's data, I would look at each survey point to determine distance to edge and type of edge. And I would determine just how much, if any, 'edge' habitat was surveyed and the kind of 'edge' habitat, to determine the extent to which Keeyask Generation Project surveyed, if at all, the *a priori* optimum olive-sided flycatcher habitat (i.e., habitat based on literature). Even an audit may not discover problems of data collection and management, as some will discard data for various reasons and may not record such an activity or the reasons for discarding the data. For example, data collected to test/validate a Manitoba American marten habitat model were discarded by a contractor under the supervision of a senior Manitoba Natural Resources biologist without indicating that this had occurred. Upon being discovered, the reason given by the contractor was that the data were discarded "because they did not support the model". The only reason I discovered this particular transgression of monumental ignorance was because I was present during some of the data collection, and recognized that some of the data were missing when I read the model validation report. After that, nothing would surprise me in terms of how people use and abuse data.

The Olive-Sided Flycatcher Habitat Model – Some Observations

After review of the olive-sided flycatcher habitat model in the draft report (Ecostem et al. 2013), I make the following observations relative to errors and issues of data analysis.

- Table 7-1.
    - Table 7-1 includes numbers on six different 'Young generation' broad habitat types, indicating that only one of the types was sampled with a total area of 0.01 ha. It is relevant to note that the area of one 75-m radius plot is 1.77 ha. In conflict with this information is Table 7-2 which indicates that four of the six habitats were sampled, and that the 'Young

regeneration' broad habitat types represented 7.9% of the samples from the 'primary' and 'secondary' habitat. Clearly one or both of these tables are quite wrong.
    - Within Keeyask Generation Project and/or Ecostem et al. (2013), it was indicated that some plots were sampled more than once. This should have been footnoted at the bottom of Tables 1 and 2.
- Table 7-4 reports on observations of flycatchers over the period 2001 to 2012.
    - The sample sizes for the various cells in the Table are required to even begin to evaluate the data as presented, but these are missing.
    - Within Keeyask Generation Project and/or Ecostem et al. (2013), it was indicated that some plots were sampled repeatedly over two or more years. These data should have been treated somewhat differently to avoid what is known as pseudo-replication. This is a potentially very significant problem because pseudo-replication leads to liberal conclusions, i.e., conclusions of greater confidence than warranted. Again, it would be necessary to audit the raw data to determine to what extent this matter influenced conclusions. E.g., what is the total number of independent sites?
    - Ecostem et al. (2013) state "Based on field observations, the broad habitats with the highest recorded densities of olive sided flycatcher include; 1) black spruce dominant on ground ice peatland … Table 7-4". The statement is not supported by the data in the Table. For example, the mean number of singing males per ha was 0.036 for 'black spruce dominant on ground ice peatland' (average of means of 9 years of observations) and essentially equivalent at 0.031 for 'trembling aspen dominant on all ecosites' (average of means of 9 years of observations). Without an understanding of sample sizes for the given years, and which sample locations were sampled over multiple years, the only recourse given Table 7-4 is to average annual estimates. And one simply cannot make the statement made by the proponent on the basis of the data in the Table.

Basis for focus within 50 m of edges

Keeyask Generation Project's olive-sided flycatcher model is described within Table 7-3 of Ecostem et al.'s (2013) draft report. However, the basis for much of the material is not provided, nor are there data to support much of the material. For example, what is the basis and where are the data to support the focus on the area within 50 m of edges? Why is this not 32 m, 66 m, or 120 m? I.e., a number with an empirical basis. This looks to be a case of picking a number out of the air simply for the sake of having a number, or 'winging it'. Similarly, what is the basis for the focus on regenerating forests of between 5 and 15 years? Did Keeyask Generation Project's consultants sample any younger or older regenerating forests? If not, what does the literature tell us on this matter? If it was me auditing Keeyask Generation Project's raw data, I would attempt to determine the extent to which Keeyask Generation Project's samples were within 50 m of an appropriate edge.

In its draft report, Ecostem et al. (2013) state that “As the majority of field observations fell within habitat identified as primary or secondary habitat, the model appears to perform well.”. However, the ‘evidence’ provided by Keeyask Generation Project’s consultants (Ecostem et al. 2013) does not support the statement.

- Consider that there were 39 observations of flycatchers in the 2011 and 2012 plots, of which 23 (59%) were in ‘primary’ or ‘secondary’ habitat and almost half (41%) were in ‘non-habitat’ per the model. This seems like a lot of observations in ‘non-habitat’ at face value. How many samples were in the ‘primary’ and ‘secondary’ habitat, and how many were in other habitats during those years? This information is required to evaluate the veracity of Ecostem et al’s (2013) statement. There were 171 samples in 2011 and 38 samples in 2012 for a total of 209. Let us assume that 150 of these samples were in ‘primary’ and ‘secondary’ habitat, and 59 samples were in ‘non-habitat’. If that were the case, flycatchers would have been found in 15% of the ‘primary’ and ‘secondary’ habitat plots, and 27% of the ‘non-habitat’ plots, and such a finding would indicate that the model was fatally flawed.
- Irrespective of the above aspect, it seems irresponsible to ignore almost half of the observations, to discount those observations as being of no value in relation to those in support of the model. Why did Ecostem et al. (2013) ignore almost half the observations? Why does that habitat not count? In a sense, this seems like the situation earlier described for the American marten model, where the evaluator chose to consider only data that support the model.
- Given that such a high proportion of the observations were outside of the ‘primary’ and ‘secondary’ habitat, and without the benefit of the required information, at face value it seems that serious consideration should have been given to altering the model. One wonders what kind of evidence it would take for Keeyask Generation Project to alter its model.
- Finally, one wonders whether the data demonstrated a difference between the ‘primary’ and ‘secondary’ habitats. Keeyask Generation Project suggested the distinction, and therefore it seems only reasonable that Ecostem et al. (2013) would have provided the comparison. Where is it? Again, more fodder for the contention that an audit of the data is in order.

Shortcoming of EcoStem model

Earlier, it was pointed out that density is not an indicator of fitness for olive-sided flycatcher during breeding, at least when the species can select logged forests. Clearly, as an indication of habitat quality, there is a demonstrated need to collect data on reproductive success for this species. A significant shortcoming of Keeyask Generation Project’s habitat quality model is that the data upon which it is founded did not include reproductive success. Consequently, in the absence of such data, the habitat quality model for the threatened olive-sided flycatcher should be viewed to have a high level of uncertainty.

Noteworthy, given that development in the form of logging is viewed to significantly and adversely impact the species, is Ecostem et al.'s (2013) finding that olive-sided flycatcher made use of the 'Human infrastructure' broad habitat type (Table 7-4). This is of concern given the nature of the development proposed by Keeyask Generation Project. Indeed, respecting development like roads and transmission lines, Ecostem et al. (2013) stated "This habitat fragmentation creates more edge habitat, which may be used by olive-sided flycatcher.".

The Local Study Area and the Regional Study area both include area within Forest Management Unit 86 and outside the commercial Manitoba Forestry Zone (i.e., these Study Areas are a the very edge of the commercial zone). This is an important consideration because fires are typically not fought to preserve forest industry values outside of the commercial zone, and economics over the long-term may very well shrink the realistic commercial zone in this area, if that has not already occurred. Given this, it is likely that significant portions of these areas will burn over time. Consequently, if burns are quite important for olive-sided flycatcher, as suggested by the scientific literature, these areas could become of significantly greater importance in the future.

Some Conclusions and Recommendations – The 'Larger Picture'

I offer the following more important conclusions and recommendations, in the context of the 'larger picture'.

- Fuller (2012b) noted that density "appears to correlate with reproductive output in a high proportion of cases … but … density can be misleading" and "wherever possible it is advisable to test relationships between density and breeding productivity. Alternatively, adopting an independent surrogate measure alongside density would increase confidence that habitats of highest quality were being correctly identified.". We have seen for the threatened olive-sided flycatcher that simply determining habitat occupancy ('density') by counting breeding males, as done by Keeyask Generation Project, is not appropriate as an indicator of realised habitat quality. Indeed, 'density' for this species can counter-indicate the realised quality of habitat, and cause the uniformed to erroneously conclude that sink habitat is of high value. Clearly, for this species, it is necessary to determine nest success to understand realised habitat quality. Given the clear disconnect that can occur between 'density' and habitat quality, at the very least, Keeyask Generation Project should have attempted to measure nest success.
- The realised habitat found within Keeyask Generation Project's area of interest may be of particularly high value for olive-sided flycatcher in the context of the larger Manitoba and North American landscape where forests are being logged. This context is important to understand to properly value the habitat.

- For avian species at risk, we should go beyond simply trying to count the number of breeding pairs, as done for common species like American robin, where this can be done. Even within a terrible EIS on a peat mine proposal (KGS Group 2011), it was recognized that it would be appropriate to conduct “periodic observations of bird nesting and rearing activities and success“. Going forward, there should be an onus on a proponent to, at the very least, attempt to recognize and understand the realised habitat quality for species at risk. To at least attempt to provide a sense of whether the habitats to be impacted are sources or sink. At the same time, for such species, determining nest success may not always be feasible, and the study of the species should not itself significantly compromise nest success and survival.
- Although Ecostem et al. (2013) are silent regarding how close the songbird plots were located to edges, what is clear is that breeding bird surveys designed to locate plots away from edges, as done in the past, are not appropriate for olive-sided flycatcher. For breeding songbird species that are at risk, survey designs must be appropriate to their biology.
- On the basis of what I have seen from Ecostem et al. (2013) and TetrES (2004), there is a need for an audit of Keeyask Generation Project’s olive-sided flycatcher data to understand the extent to which plots incorporated multiple coarse habitat types, and to determine the relationships between plot locations and edge. There is simply far too much uncertainty respecting this dataset. Subject to the findings of the audit, there may be a need to conduct further survey, including near edges and possibly within burns, to ensure that there is an accurate understanding of the realised habitat quality of Keeyask Generation Project’s area for olive-sided flycatcher. Respecting an audit, I would be happy to provide some names of people who I view to be competent, credible, and objective.
- Robertson (2012) suggested mitigation strategies for olive-sided flycatcher in landscapes where logging occurs. I did not examine Keeyask Generation Project’s proposed mitigation for the species; however, Keeyask Generation Project should consider the feasibility of those strategies in the context of the effects on other species. Compensation, as occurs in BC for species at risk, should be considered if Keeyask Generation Project has not done so.
- Olive-sided flycatcher made use of ‘Human infrastructure’ within the Keeyask Generation Project’s area. Given the findings from logged forests in the USA, such novel habitat, including the habitat that will result from the Keeyask Generation Project development (e.g., the hard edges that result from roads and transmission lines, may result in population sinks. Consider that in some environments, nest success can be quite low in the vicinity of hard edges. The effects monitoring will have to closely monitor the use of such habitats by olive-sided flycatcher, including nest success. Given the potentially substantial impact of the Manitoba forestry industry on the species, Keeyask Generation Project should attempt to partner with the forestry industry to fund a graduate student research project on the species realiased habitat quality in the area of interest. Such a project would best be supervised by a professor in a science/biology department (i.e., through a body granting a science

degree like a M.Sc.) as opposed to, for example, an institute granting a Masters of Natural Resource Management type of degree. In my view, science is best conducted by those training to study science with supervisors who are scientists, as opposed to those taking an interdisciplinary type of degree.

- I could not evaluate whether Keeyask Generation Project's olive-sided flycatcher habitat quality model was 'valid', whether it was 'good' or 'bad', 'useful' or without value. The information provided by Ecostem et al. (2013) was simply inadequate to allow for an objective evaluation, given, for example, the lack of clarity around plots with multiple coarse habitat types, and the absence of clarity around the extent to which plots were located near edges.
- The test of the beaver habitat quality model was not appropriate for scientific and technical reasons. In the absence of a suitable test, one cannot evaluate whether the model 'works' or not. However, Ecostem et al.'s (2013) failure to understand the trees and shrubs located further than 50 m from a shoreline should not be considered to be realised habitat, and their failure to appropriately recognize the relative importance of aquatic plants to the diet of beaver, does not instill confidence in their model, irrespective of the problems with their test.
- Failure of the beaver habitat quality model is, at least in terms of biodiversity, of relatively limited concern. Beaver are a common species that, at present, is generally little exploited by humans in Manitoba. If Keeyask Generation Project's predictions are wrong, even terribly and adversely wrong, the population of Manitoba beaver would still be very high. Where Keeyask Generation Project's predictions may be problematic is in valuing the habitat of, for example, areas that would be flooded. This has implications to appropriately valuing the habitat for the purpose of compensation to those who make use of the beaver resource. Another consideration respecting valuation is that fire, in particular, imposes change across boreal landscapes, and habitat could change for the better, and perhaps considerably so, when fires occur in the future. When we consider habitat loss, we should not think only about the habitat found on the landscape at one point in time. We should also be thinking about how that habitat would change in time in the absence of the development.
- Constraints limited my examination to two of the six habitat quality models in Ecostem et al.'s (2013) draft report. Consequently, I have no basis to conclude one way or the other as to their veracity. However, my examination of the beaver and olive-sided flycatcher models suggests that I would have a considerable number of questions and concerns, and has not instilled me with confidence.