Marten Habitat Analysis

1. Overview

In the development of HWP's 2014 Detailed Forest Management Plan, ESRD wanted habitat modelling undertaken for American marten (*Martes Americana*; hereafter: marten) on the Hinton FMA area. As the marten is not a threatened or endangered species, HWP was reluctant to carry out such modelling. In addition, HWP felt strongly that managing cover types and seral stages within their Natural Range of Variation addressed marten habitat.

It was subsequently agreed that ESRD would carry out habitat modelling for HWP, and the results of that modelling would be presented in the DFMP.

What follows is an explanation of the marten model (supplied to HWP by ESRD) and then the ESRD results (in a table and maps) of the modeling are presented.

2. Marten and Model Information

The model used for this habitat analysis is called the "American Marten Winter Habitat Suitability Index Model (Version 5 Last Modified: 25 October 1999). It was developed by Lisa Takats, Robert Stewart, Melissa Todd, Richard Bonar, James Beck, Barbara Beck, and Richard Quinlan. The following sections are taken from the model description written by the above noted persons, and provide an overview of marten physiology and describe the model in more detail (L Takats et al, 1999):

2.1. Introduction

Habitat Suitability Index (HSI) models predict the suitability of habitat for a species based on an assessment of habitat attributes such as habitat structure, habitat type and spatial arrangements between habitat features. This HSI model for the marten (*Martes americana*) applies to habitats in the Foothills Model Forest (FMF) in west-central Alberta. The intended use is to predict habitat suitability at landscape scales and over long-time periods. The model will be used to determine potential changes in marten habitat area and carrying capacity throughout an entire forest management cycle (200 years). The model was primarily developed through a literature review and Stewart's telemetry study.

2.2. Species Description and Distribution

The marten is a medium sized member of the weasel family (*Mustelidae*), with a long slender body (55-65 cm), glossy dark brown to buffy fur, and short limbs with flattened semi-retractile claws that are adapted for an arboreal lifestyle (Banfield 1987). The tail is long and bushy and the ears are conspicuous (Banfield 1987). The average male mass of about 995 g is 15% greater than the average female mass (Banfield 1987).

Marten are found in boreal forests across Canada and the U.S (Banfield 1987). They are primarily associated with mature and old growth forests. Their distribution once coincided closely with the belt of coniferous forest running across North America, but because of habitat loss and trapping, they only remain in pockets in the northern part of their range (Banfield 1987). In Alberta, marten are not at risk and their habitat appears secure (Wildlife Management Division 1996). They comprise most of the value of the local furbearer harvest on the FMF (Alberta Government Fur Harvest Database).

The marten's long, thin body has a high surface area to mass ratio, which causes a high rate of heat loss. The fur is relatively thin (Brown and Lasiewski 1972, Buskirk et al. 1988 as cited in Lofroth and Steventon 1990) and there is little fat reserves to provide insulation or metabolic energy (Buskirk et al. 1988 as cited in Lofroth and Steventon 1990). Marten must remain active to remain warm and at other times marten require a well-insulated den (Buskirk et al. 1989).

Average longevity of the marten in the wild is 5-6 years but some have been known to live as long as 14 years (Strickland and Douglas 1987). Predators include fisher (*Martes pennanti*), coyote (*Canis latrans*), lynx (*Felis lynx*), great-horned owl (*Bubo virginianus*), and golden eagle (*Aquila chrysaetos*) (Banfield 1987).

2.3. Food
The marten is a generalist predator and will switch prey species when the preferred food source is not readily available (Ben-David et al. 1997). Voles (*Microtus* spp. and *Clethrionomys* spp.) are the preferred prey (Cowan and Mackay 1950, Soutiere 1979, Thompson and Colgan 1987, Thompson and Curran 1995). Marten also eat red squirrels (*Tamiasciurus hudsonicus*), flying squirrels (*Glaucomys spp*), chipmunks (*Eutamias spp*), grouse (*Tetraonidae*) and smaller birds, eggs, snowshoe hares (*Lepus americanus*), pikas (*Ochotona princeps*), mice (*Peromyscus spp*), shrews (*Sorex spp*), amphibians, insects and fish (Marshall 1946, Cowan and Mackay 1950, Steventon and Major 1982, Douglass et al. 1983, Buskirk and MacDonald 1984, Hargis and McCullough 1984, Banfield 1987, Thompson and Colgan 1987, Lofroth and Steventon 1990).

Marten will eat winter-killed ungulates (Ben-David et al. 1997), which can compromise up to 32% of their spring diet. In summer, marten eat berries, (Cowan and Mackay 1950, Steventon and Major 1982, Thompson and Colgan 1987) and nuts (Strickland and Douglas 1987) which can amount to 31% of the marten's diet (Ben-David et al. 1997).

During the winter, marten often forage beneath the snow. Access may be provided by coarse woody debris (leaning logs and trees, decayed or overturned stumps, snags; Bateman 1968, Steventon and Major 1982, Buskirk et al. 1989), large rocks, trees or saplings (Bateman 1968, Allen 1982, Steventon and Major 1982, Hargis and McCullough 1984, Buskirk et al. 1989). In lodgepole pine forests in Yellowstone National Park, marten used access points that were associated with a high abundance of small mammals and to a lesser extent coarse woody debris (Sherburne and Bissonette 1994). Thompson and Curran (1995) had a similar finding in balsam fir forest of Newfoundland at snow depths of 1 m. Thompson and Colgan (1994) suggested that coarse woody debris may not be a limiting feature for marten in coniferous and logged sites in Ontario. This may be because in their study area, marten hunted mainly above the subnivean zone for snowshoe hares and thus did not rely on subnivean access to prey (Thompson and Colgan 1994). Downed logs were the preferred access points during low snow periods in lodgepole pine, spruce, and fir forests in the central Rocky Mountains (Corn and Raphael 1992). However, during periods of high snow cover, small live spruce and fir trees were more commonly used as access structures (Corn and Raphael 1992).

In the Foothills area, marten were not associated with downed wood (R. Stewart, Habitat suitability index model: marten, poster presented at the Alberta Chapter of the Wildlife Society, March 1994, University of Calgary, Calgary, Alberta.). Instead marten were commonly found on sites containing 1% ground cover of downed wood (R. Stewart, MSc. Candidate, University of Alberta, personal communication). It is likely that marten used other means to access the subnivean zone (around stumps, or trees) and found alternative denning sites rather than relied on downed wood for these activities. In northern Utah, marten were not associated with down wood (Hargis et al. 1999).

2.4. Cover
Mature to old coniferous forest is generally considered good marten habitat (Allen 1982, Buskirk 1984, Strickland and Douglas 1987). These forests are associated with large diameter downed wood used for winter dens, large-diameter standing trees used for natal dens, and prey populations important to marten (Allen 1982, Buskirk 1984, Strickland and Douglas 1987, Buskirk and Powell 1994). Vertical and horizontal structure may be more important in providing suitable marten habitat than forest age, or forest composition (Buskirk and Powell 1994, Chapin et al. 1997).

The winter is a difficult period for martens (Lofroth and Steventon 1990), so this model is based on food and cover associated with winter habitat. Because of their physiology and body shape, marten require winter dens during extreme winter conditions (Buskirk et al. 1989). These dens are typically in squirrel middens (Buskirk 1984), rock piles (Buskirk et al. 1989), hollow logs and stumps (Steventon and Major 1982, Buskirk et al. 1989), uprooted trees (Buskirk et al. 1989), snags (Batemen 1968) and in warmer weather up in the tree canopy (Steventon and Major 1982, Buskirk 1984).

Open areas that have no overstory or shrub cover are generally avoided (Spencer et al. 1983, Hargis and McCullough 1984, Wynne and Sherburne 1984, Buskirk and Powell 1994). This avoidance is pronounced during the winter (Soutiere 1979, Steventon and Major 1982) when snow cover makes it difficult to access the subnivean layer (Hargis and McCullough 1984). Areas of isolated habitat may be used if linked by travel corridors or islands of forest cover and coarse woody debris (Soutiere 1979, Steventon and Major 1982), however, landscapes with > 25% non-forest cover may still not be used by marten (Hargis et al. 1999).

In general, tree canopy cover < 30% is not suitable (Bateman 1968, Allen 1982, Spencer et al. 1983, Buskirk 1984). However, tree canopy cover is not always essential if other cover is available. In Maine, Chapin et al. (1997) suggested that overhead cover requirements were provided in mature deciduous dominated forests and forests regenerating after spruce-budworm with <30% canopy cover. These stands were 10-12 years old with an understory of deciduous and coniferous vegetation, many snags, and high volume of logs and root mounds that provided suitable vertical and horizontal structure. In lodgepole pine forests in Yosemite National Park, marten preferred areas with overhead cover that was less than 3 m above the snow surface and were not selecting dense forest stands (Hargis and McCullough 1984). Dense canopy cover is thought to be associated with low small mammal numbers and therefore a smaller food base for marten. In the Foothills area, Stewart found marten using stands with a 6-30% canopy closure in a few cases (R. Stewart, MSc. Candidate, University of Alberta, personal communication).

Spruce (*Picea spp*.) or fir (*Abies spp*.) in the canopy improves the habitat value of forest stands for marten (Bateman 1968, Allen 1982, Buskirk 1984) since the dense lower branches provide good security and thermal cover and access to subnivean habitat. Stands of at least 40% spruce or fir species composition provide suitable winter habitat (Allen 1982).

2.5. <u>Reproduction</u>

The marten is a solitary animal. Males are aggressive and polygamous, and are only associated with females during breeding times. Mating takes place from July and August (Banfield 1987). Delayed implantation occurs, with young born the following March or April (Banfield 1987). Gestation is 220-275 days and parturition is in 28 days (Banfield 1987). Females give birth to litters averaging 2.6 (range: 1-5) young that are helpless, blind, deaf, and almost naked (Banfield 1987). The young open their ears within 26 days and open their eyes within 39 days (Strickland and Douglas 1987). Weaning takes place in 6 weeks (Strickland and Douglas 1987). Marten mature as early as 15-17 months, but most individuals take 2 years to reach sexual maturity (Banfield 1987).

Young are born and raised in whelping dens, which can be leaf-lined nests in trees cavities (Wynne and Sherburne 1984), fallen logs, old stumps or root masses of large trees (Hargis and McCullough 1984, Wynne and Sherburne 1984), rock dens (O'Neil 1980, Ruggiero 1998) or squirrel middens (Ruggiero 1998). Average tree canopy cover around natal (where kits were born) dens in southern Wyoming was 67% (Ruggiero 1998). The average number of maternal dens (sites where kits were brought after birthing) per marten was 10.8 (range 5-24, n = 9 females; Ruggiero 1998). Canopy cover around maternal dens averaged 58%.

2.6. <u>Habitat Area</u>

Most mustelids are considered intrasexually territorial which means that home ranges are exclusive within but not between sexes (Katnik et al. 1994). Male marten have home ranges 2-3 times larger than females and will overlap the home ranges of several females (Stickland and Douglas 1987, Buskirk and McDonald 1989). During the mating season, males may wander more extensively looking for mates and tend to have larger home ranges (Buskirk and McDonald 1989). Summer home ranges of male and female marten in northwestern Maine were 5.6 km^2 and 2.9 km^2 respectively (Wynne and Sherburne 1984). In Newfoundland, the winter home range of a male was 27.5 km^2 and a female was 17.7 km^2 (Bateman 1968). These home ranges in Newfoundland are large likely because the habitat did not provide food in the quantity normally found in marten habitat in other parts of its range (Bateman 1968). The median home range of marten in Maine in summer was 2.58 km^2 and 1.95 km^2 for males and females respectively and the winter home ranges were 2.11 km^2 and 1.73 km^2 for males and females respectively (Phillips et al. 1998). In Ontario, home ranges of males and females when food was abundant were 3.35 km^2 and 1.00 km^2 respectively and 6.80 km^2 and 4.25 km^2 respectively, when food was scarce (Thompson and Colgan 1987).

Densities of marten in uncut and harvested spruce/fir forests in Ontario were 0.8-1.8 marten/km^2 and 0.05-0.2 marten/km^2 respectively (Thompson 1994). In uncut and partially cut spruce/fir forests in Maine, average density was 1.2 adults/km^2 during the summer, which increased to 2.22 martens/km^2 in the fall (Soutiere 1979). Average winter density of marten in Algonquin Park, Ontario was 0.6 adults/km^2 (Strickland and Douglas 1987).

To be considered suitable, isolated habitat should be 15 ha or larger (Snyder 1984). In an extensively logged landscape in Maine, marten were in 27 ha (median size) forested patches but absent in 1.5 ha (median size) patches (Chapin et al. 1998). Patches that were used were closer to nearby patches. Marten used small residual patches but required larger patches to support their home range (Chapin et al. 1998). Female home ranges averaged 260 ha and contained mostly residual forest but there was always a contiguous patch of 150 ha (median value). Male home ranges averaged 450 ha and were dominated by a single contiguous patch with a median size of 247 ha (Chapin et al. 1998). Marten tolerated a median of 20% regenerating clearcuts in their home ranges and maximum values were 40% and 31% for individual males and females respectively (Chapin et al. 1998).

Marten populations often follow the cyclic patterns of their prey, particularly those of small mammals and hares. In Ontario, fall density with high prey abundance was 2.4 marten/km^2, which dropped to 0.4 marten/km^2 in a spring with low prey abundance (Thompson and Colgan 1987). This sudden reduction in marten population size can have serious repercussions on small or isolated populations by potentially extirpating marten from these areas (Thompson and Colgan 1987).

2.7. Habitat Suitability Index Model

2.7.1. Model Applicability

Species: Marten (*Martes americana*).

Habitat Evaluated: Winter habitat (cover and foraging).

Geographic area: This model is applicable to the Foothills Model Forest in west-central Alberta.

Seasonal Applicability: This model predicts winter habitat (cover and foraging).

Cover types: This model applies to all forest and non-forest habitat areas of the Lower and Upper Foothills, Montane and Subalpine Natural Subregions (Beckingham et al. 1996). The model should also be broadly applicable to other habitat areas dominated by similar tree species, including boreal deciduous, mixedwood and coniferous forest types, as well as wetland and riparian forests, meadows, shrublands, and areas regenerating after forest harvesting.

Minimum Habitat Area: Minimum habitat area is defined as the minimum amount of contiguous habitat to which the model will be applied. Snyder (1984) recommends 15 ha as a minimum. Thus a minimum habitat area of 15 ha is placed on the model application.

Model Output: This model will produce Habitat Units (HU) for all cover types for their suitability as winter marten habitat. HU are calculated by multiplying the HSI score for the stand with the hectares of the stand. The performance measure for the model is potential carrying capacity (number of marten per ha). Model output (HU) must be correlated to estimates of carrying capacity to verify model performance.

Carrying Capacity (Marten per hectare where HSI = 1.0): Based on Soutiere (1979) and Thompson (1994) the current estimate of the maximum number of marten per optimal hectare (HSI = 1.0) is 0.02.

Verification Level: Preliminary data collected within the Foothills Model Forest by Rob Stewart for a marten research graduate program was used to develop version 2 of the model in 1994. The Stewart graduate program is incomplete. The reliability of this model has not been evaluated against local data. The verification level is 4: local data used to develop model, but model predictions not tested.

Application: This HSI model is designed to assess habitat suitability for relatively large forest landscapes using generalized species-habitat relationships and stand-level vegetation inventory. Its purpose is to predict relative changes in marten habitat supply at the landscape level over long time periods (200 years), for integration with forest management planning. The model is not designed to provide accurate prediction of suitability or use at the stand level. Approximate population size can be calculated by assuming linear habitat-population relationships, but the model is not designed to provide accurate population density estimates. Any attempt to use the model in a different geographic area or for other than the intended purpose should be accompanied by model testing procedures, verification analysis, and other modifications to meet specific objectives.

2.8. Model Description

The HSI model for marten assumes that life requisites of winter food and cover are limiting. Food is assumed to be associated with the same habitat features that provide suitable cover. Cover is represented by a combination of thermal and hiding cover.

2.8.1. Habitat Variables and HSI Components

Habitat suitability for marten is determined from four elements of habitat structure for areas within the FMF. The first component (S1) is tree canopy closure which provides cover for thermal and protective needs as well as supplying habitat for various prey species (Table 1). Marten prefer intermediate canopy closure, and are less likely to be associated with very high or low canopy closure. The second component (S2) is the percentage of spruce and fir in the canopy. Spruce and fir provide optimal cover due to their evergreen branches, which tend to be fuller and closer to the ground than other conifer and deciduous trees. S3 is determined based on the tree canopy height. Taller trees are associated with mature forests that tend to have more structure and more thermal shelter and food resources for marten prey species. Finally, S4 provides some cover in stands with a pine component. This component has been added to ensure that pure deciduous stands will get a suitability rating of zero but pine forests can get a suitability rating of one (Table 1). An earlier version of this model had downed woody material as a habitat variable but because there was little association between martens and downed wood in the FMF, this component was removed from the model.

Table 1 – *Relationship of habitat variables to life requisites for the marten HSI model*

HSI Component	Life Requisites	Habitat Variable	Habitat Variable Definition
S1	Food & Cover	Tree Canopy Closure (%)	Percent of ground covered by a vertical projection of tree crown areas onto the ground. Includes all trees ≥ 8cm diameter at breast height (1.3 m).
S2	Food & Cover	Spruce + Fir in Tree Canopy (%)	Percent composition of all spruce and fir species in the tree canopy.
S3	Food & Cover	Tree Canopy Height (m)	Average top height of 100 trees/ha that have the largest diameter at breast height (dbh at 1.3 m).
S4	Food & Cover	Pine, Spruce and Fir in Tree Canopy (%)	Percent composition of all spruce, fir and pine species in the tree canopy.

2.8.2. Graphical HSI Component Relationships

S1 – Tree canopy closure is suitable at moderate crown closures. Marten will use low density stands, so suitability has been set to increase over the range 6-30% crown closure. The optimal canopy closure for the marten is assumed to be ≥ 31% but ≤ 70%. From 71-100% suitability decreases to reach 0.3 at 100% canopy closure (Figure 1a).

S2 – Suitable habitat for marten contains greater than 50% spruce + fir. The suitability index is 0.2 at 0%, increases to 1 at 50% then remains at 1 for all higher values (Figure 1b).

S3 – The mean canopy height must be > 5 m before a stand will be suitable. The suitability in relation to height then increases to the optimum condition at 15 m and taller (Figure 1c).

S4 – This component has been added to account for the lack of suitability of pure deciduous stands and allow pine forests to act as partially suitable habitat. When there is no conifer in the stand, the component value is 0.

2.8.3. Model Assumptions

1. Marten can obtain water and mineral resources in areas that supply food and cover habitat.
2. The life requisites of food and cover are equally limiting and are provided by the same habitat structures.
3. Potential den site and suitable summer and reproductive habitat will be met by the same parameters that provide essential winter food and cover.
4. Marten are not affected by proximity to human settlements, roads, or other activities in this model.

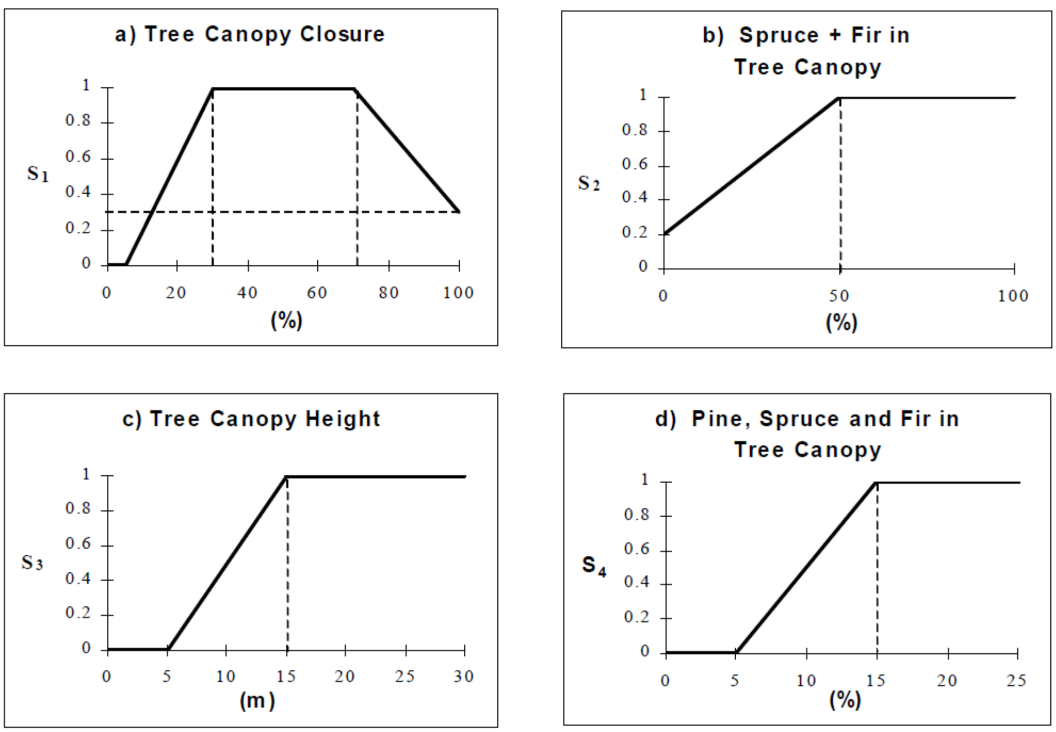

Figure 1- *Graphical relationships between habitat variables and HSI components in the marten model*

2.8.4. Equation

Component S4 is left untransformed, whereas the other variables are square root transformed. Thus, S1, S2 and S3 are compensatory such that a high score in one variable can compensate for a low score another.

HSI = S4 x (S1 x S2 x S3)1/2

For example, with S2, S3, and S4 all equal to 1 and S1 equal to 0.1, the HSI score = 0.32 since that is the square root of 0.1. If S4 = 0.1 and all others are equal to 1 the HSI = 0.1.

2.9. Sources of other Models
The original HSI model for the American marten was developed for the US Fish and Wildlife Service (Allen 1982). A version of this model exists for Manitoba (Manitoba Forestry Wildlife Management Project 1994).

2.10. Model History
All of the HSI models for the Weldwood Forest Management Area have undergone several revisions, and they will be revised again as new information becomes available. Contact Rick Bonar for information about the most current version.

- Version 1 (1989) was developed by the Weldwood of Canada Integrated Resource Management Steering Committee (IRMSC).
- Version 2 (1994) was revised by Barb Beck and Melissa Todd, using local information from a telemetry-based marten research study conducted within the Foothills Model Forest by Rob Stewart.
- Version 3 (1995) was written by Lisa Takats for a special topics course in habitat modelling at the University of Alberta.
- Version 4 (1996) was edited and reformatted by Wayne Bessie and sent to species experts for critical comment.
- Version 5 (1999) was revised by Karen Graham, Rick Bonar, Barb Beck, and Jim Beck to incorporate reviewer comments and information from recent literature.

2.11. Literature Cited
The following is a list of the literature cited in the development of the model:

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3. Model Results

Table 2 is a roll-up of the model results as provided to HWP by ESRD:

Table 2 - *Marten Habitat Suitability Index Model Results*

Planning Unit	Compartment	Current Marten Mean Habitat Suitability Index	20y Marten Mean Habitat Suitability	Change	Change in Mean Habitat Suitability Index
16141	Athabasca 13	0.246	0.370	0.124	50.4%
16142	Athabasca 9	0.489	0.390	-0.099	-20.2%
16143	McLeod 19	0.221	0.105	-0.116	-52.6%
16144	Athabasca 8	0.441	0.342	-0.100	-22.6%
16321	McLeod 12	0.371	0.276	-0.095	-25.7%
16322	McLeod 18	0.254	0.158	-0.095	-37.6%
16323	Athabasca 1	0.311	0.224	-0.088	-28.1%
16324	Athabasca 20	0.250	0.255	0.005	2.1%
16325	Athabasca 3	0.360	0.336	-0.023	-6.5%
16326	McLeod 15	0.354	0.364	0.010	2.9%
16327	McLeod 27	0.406	0.285	-0.121	-29.8%
16328	Athabasca 6	0.522	0.511	-0.012	-2.2%
16329	Athabasca 2	0.424	0.385	-0.039	-9.3%
16330	McLeod 17	0.233	0.167	-0.066	-28.3%
16331	Athabasca 34	0.421	0.263	-0.159	-37.7%
16332	Athabasca 16	0.198	0.321	0.123	62.0%
16333	Berland 9	0.301	0.299	-0.002	-0.7%
16334	Berland 13	0.205	0.146	-0.059	-28.7%
16335	Berland 8	0.141	0.141	0.000	0.0%
16336	McLeod 13	0.262	0.198	-0.063	-24.2%
16337	Athabasca 18	0.256	0.196	-0.060	-23.5%
16338	Athabasca 23	0.231	0.256	0.025	11.0%
16339	McLeod 16	0.376	0.338	-0.037	-10.0%
16340	Athabasca 14	0.191	0.298	0.107	56.1%
16341	Berland 34	0.422	0.415	-0.007	-1.7%
16342	Athabasca 10	0.486	0.357	-0.129	-26.6%
16344	Athabasca 35	0.309	0.234	-0.074	-24.0%
16345	McLeod 9	0.280	0.283	0.002	0.9%
16346	Athabasca 4	0.524	0.504	-0.020	-3.8%
16347	Athabasca 12	0.486	0.573	0.087	18.0%
16348	McLeod 25	0.213	0.171	-0.043	-20.0%
16349	Embarras 9	0.211	0.089	-0.122	-57.8%
16350	Berland 27	0.282	0.152	-0.130	-46.1%
16351	Berland 28	0.272	0.206	-0.066	-24.4%
16352	Berland 33	0.341	0.200	-0.141	-41.3%
16353	Berland 26	0.224	0.211	-0.014	-6.0%
16354	Athabasca 33	0.335	0.288	-0.048	-14.2%
16355	Athabasca 32	0.196	0.185	-0.011	-5.7%
16356	Berland 30	0.313	0.277	-0.036	-11.5%
16357	Marlboro 1	0.259	0.227	-0.032	-12.4%

Planning Unit	Compartment	Current Marten Mean Habitat Suitability Index	20y Marten Mean Habitat Suitability	Change	Change in Mean Habitat Suitability Index
16358	Marlboro 20	0.206	0.197	-0.009	-4.6%
16359	Marlboro 5	0.354	0.147	-0.208	-58.6%
16360	Marlboro 21	0.391	0.062	-0.329	-84.1%
16361	Marlboro 4	0.395	0.125	-0.270	-68.3%
16362	Marlboro 2	0.526	0.304	-0.223	-42.3%
16363	Berland 29	0.323	0.243	-0.080	-24.8%
16364	Berland 22	0.346	0.313	-0.033	-9.4%
16365	Berland 20	0.318	0.240	-0.078	-24.6%
16366	Marlboro 3	0.210	0.293	0.083	39.4%
16367	Marlboro 25	0.263	0.289	0.025	9.6%
16368	Berland 31	0.152	0.220	0.068	44.6%
16369	Athabasca 28	0.349	0.273	-0.077	-21.9%
16370	Berland 25	0.224	0.207	-0.017	-7.6%
16371	Marlboro 19	0.312	0.198	-0.114	-36.5%
16372	Berland 21	0.191	0.116	-0.074	-39.1%
16373	Athabasca 31	0.210	0.137	-0.073	-34.9%
16374	Marlboro 11	0.272	0.264	-0.008	-2.8%
16375	Berland 24	0.344	0.239	-0.105	-30.5%
16376	Marlboro 24	0.311	0.343	0.032	10.4%
16377	Marlboro 22	0.345	0.028	-0.318	-92.0%
16378	Marlboro 18	0.418	0.171	-0.247	-59.1%
16379	Marlboro 6	0.267	0.088	-0.179	-67.0%
16380	Berland 23	0.425	0.268	-0.158	-37.1%
16381	Marlboro 7	0.220	0.267	0.047	21.5%
16382	Marlboro 13	0.226	0.173	-0.052	-23.2%
16384	McLeod 20	0.230	0.130	-0.100	-43.6%
16385	Embarras 8	0.235	0.204	-0.032	-13.4%
16386	McLeod 28	0.680	0.692	0.012	1.7%
16387	McLeod 1	0.402	0.529	0.126	31.4%
16388	McLeod 10	0.707	0.709	0.002	0.3%
16389	McLeod 21	0.215	0.241	0.027	12.4%
16390	McLeod 5	0.329	0.238	-0.090	-27.5%
16391	McLeod 6	0.200	0.212	0.013	6.3%
16392	McLeod 7	0.334	0.294	-0.041	-12.2%
16393	Embarras 7	0.294	0.179	-0.115	-39.1%
16394	McLeod 8	0.526	0.418	-0.108	-20.6%
16395	Embarras 3	0.159	0.112	-0.048	-30.0%
16397	McLeod 23	0.360	0.192	-0.169	-46.8%
16398	McLeod 4	0.267	0.250	-0.017	-6.5%
16399	McLeod 11	0.617	0.632	0.015	2.4%
16400	McLeod 2	0.196	0.250	0.054	27.5%
16401	Embarras 15	0.317	0.241	-0.076	-24.0%
16402	Embarras 22	0.388	0.308	-0.081	-20.8%
16403	Embarras 16	0.141	0.103	-0.037	-26.6%
16404	Embarras 17	0.055	0.048	-0.007	-12.6%
16405	Embarras 18	0.457	0.311	-0.146	-31.9%
16406	Marlboro 17	0.251	0.222	-0.029	-11.6%

Planning Unit	Compartment	Current Marten Mean Habitat Suitability Index	20y Marten Mean Habitat Suitability	Change	Change in Mean Habitat Suitability Index
16407	Marlboro 16	0.320	0.207	-0.113	-35.3%
16415	Embarras 11	0.321	0.242	-0.079	-24.7%
16416	Embarras 10	0.207	0.143	-0.065	-31.2%
16417	Embarras 12	0.329	0.235	-0.094	-28.7%
16418	Embarras 2	0.231	0.077	-0.154	-66.6%
16419	McLeod 3	0.235	0.209	-0.026	-11.2%
16420	Embarras 6	0.287	0.220	-0.067	-23.2%
16421	Embarras 4	0.337	0.064	-0.273	-81.1%
16422	McLeod 24	0.338	0.177	-0.160	-47.5%
16423	Embarras 20	0.337	0.221	-0.115	-34.2%
16424	Embarras 21	0.323	0.348	0.025	7.9%
16425	Embarras 14	0.262	0.115	-0.148	-56.3%
16426	Embarras 1	0.208	0.245	0.037	17.9%
16427	Embarras 13	0.273	0.301	0.028	10.3%
16428	Embarras 5	0.273	0.302	0.029	10.7%
16432	Marlboro 15	0.274	0.228	-0.046	-16.7%
16435	Embarras 19	0.340	0.260	-0.080	-23.6%
16437	Athabasca 30	0.351	0.208	-0.143	-40.7%
16438	Marlboro 12	0.491	0.419	-0.072	-14.7%
16439	Marlboro 8	0.263	0.282	0.019	7.3%
16440	Berland 7	0.364	0.306	-0.057	-15.8%
16441	Athabasca 29	0.153	0.142	-0.011	-7.4%
16442	Berland 6	0.218	0.229	0.011	5.1%
16443	Berland 1	0.496	0.260	-0.236	-47.5%
16444	Marlboro 9	0.256	0.302	0.046	17.9%
16445	Berland 12	0.506	0.450	-0.057	-11.2%
16446	Athabasca 24	0.228	0.064	-0.163	-71.8%
16447	Berland 11	0.296	0.303	0.007	2.4%
16448	Athabasca 26	0.325	0.262	-0.063	-19.4%
16449	Berland 16	0.425	0.383	-0.042	-9.9%
16451	Marlboro 10	0.428	0.219	-0.209	-48.8%
16452	Athabasca 22	0.236	0.226	-0.010	-4.4%
16453	Berland 2	0.407	0.337	-0.070	-17.3%
16454	Berland 3	0.314	0.291	-0.022	-7.2%
16455	Marlboro 23	0.318	0.283	-0.035	-10.9%
16456	Athabasca 19	0.227	0.302	0.074	32.7%
16457	Berland 18	0.203	0.165	-0.038	-18.8%
16458	Berland 5	0.161	0.177	0.017	10.5%
16459	Athabasca 27	0.210	0.212	0.002	1.1%
16460	Athabasca 21	0.341	0.285	-0.056	-16.4%
16462	Marlboro 14	0.214	0.125	-0.088	-41.3%
16463	Berland 4	0.245	0.199	-0.046	-18.6%
16464	Athabasca 15	0.291	0.274	-0.017	-5.8%
16466	Berland 10	0.175	0.169	-0.006	-3.7%
16467	Berland 14	0.439	0.414	-0.025	-5.7%
16468	Athabasca 11	0.262	0.250	-0.012	-4.5%
16469	Athabasca 17	0.228	0.218	-0.010	-4.4%

Planning Unit	Compartment	Current Marten Mean Habitat Suitability Index	20y Marten Mean Habitat Suitability	Change	Change in Mean Habitat Suitability Index
	FMA-wide change in habitat value over 20 years of SHS	0.294	0.239	-0.055	-18.6%

Compartments with mean habitat decreasing below 0.20 threshold as a result of sequence

Compartments with mean habitat increasing above 0.20 threshold as a result of sequence

The maps on the following pages describe the gross FMA landbase showing the marten habitat suitability index at Year 0 (Figure 2), Year 20 after the implementation of the Spatial Harvest Sequence (Figure 3), and the net change in the marten habitat suitability index (Figure 4).

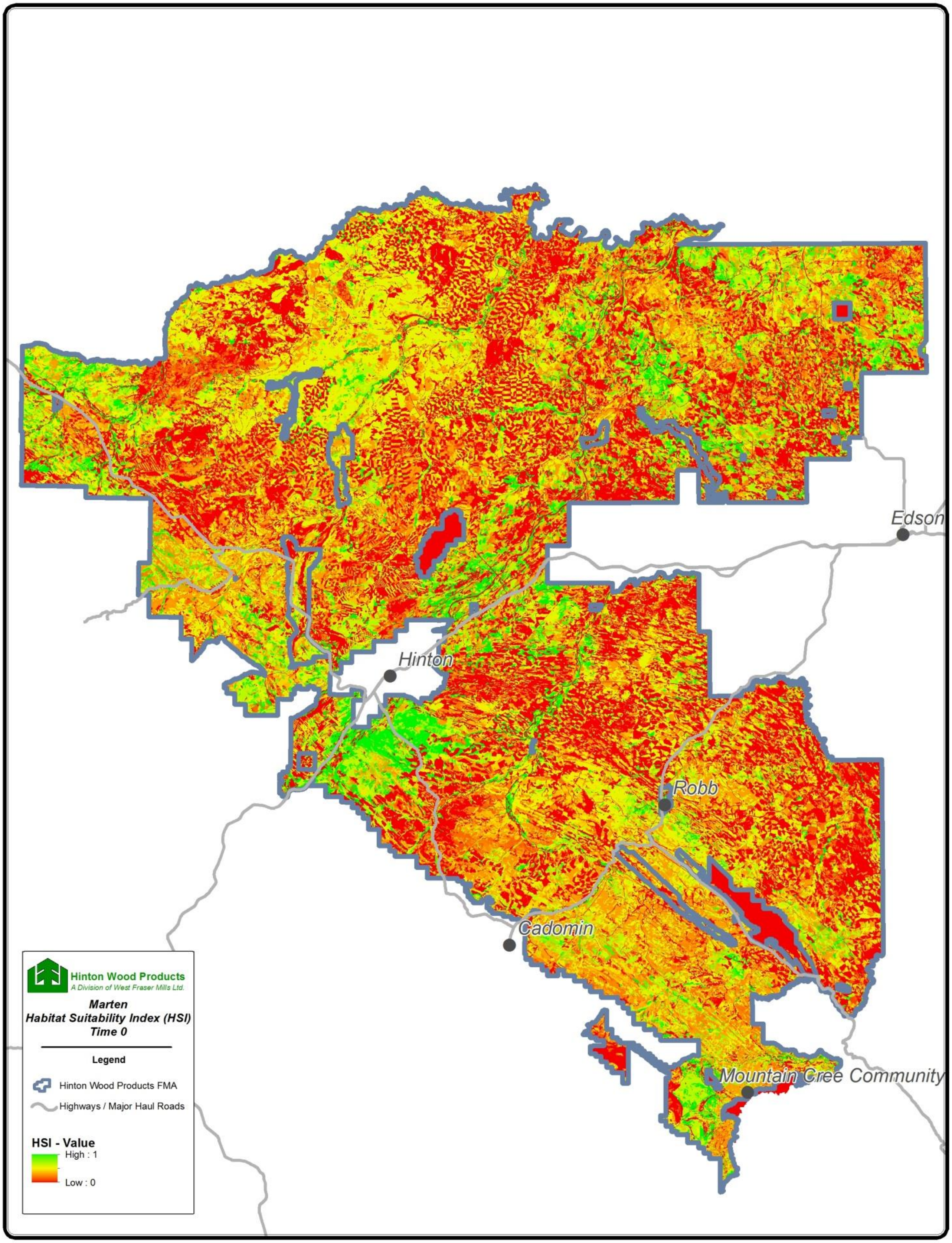

Figure 2 – *Habitat Suitability Index at Year 0 (2012)*

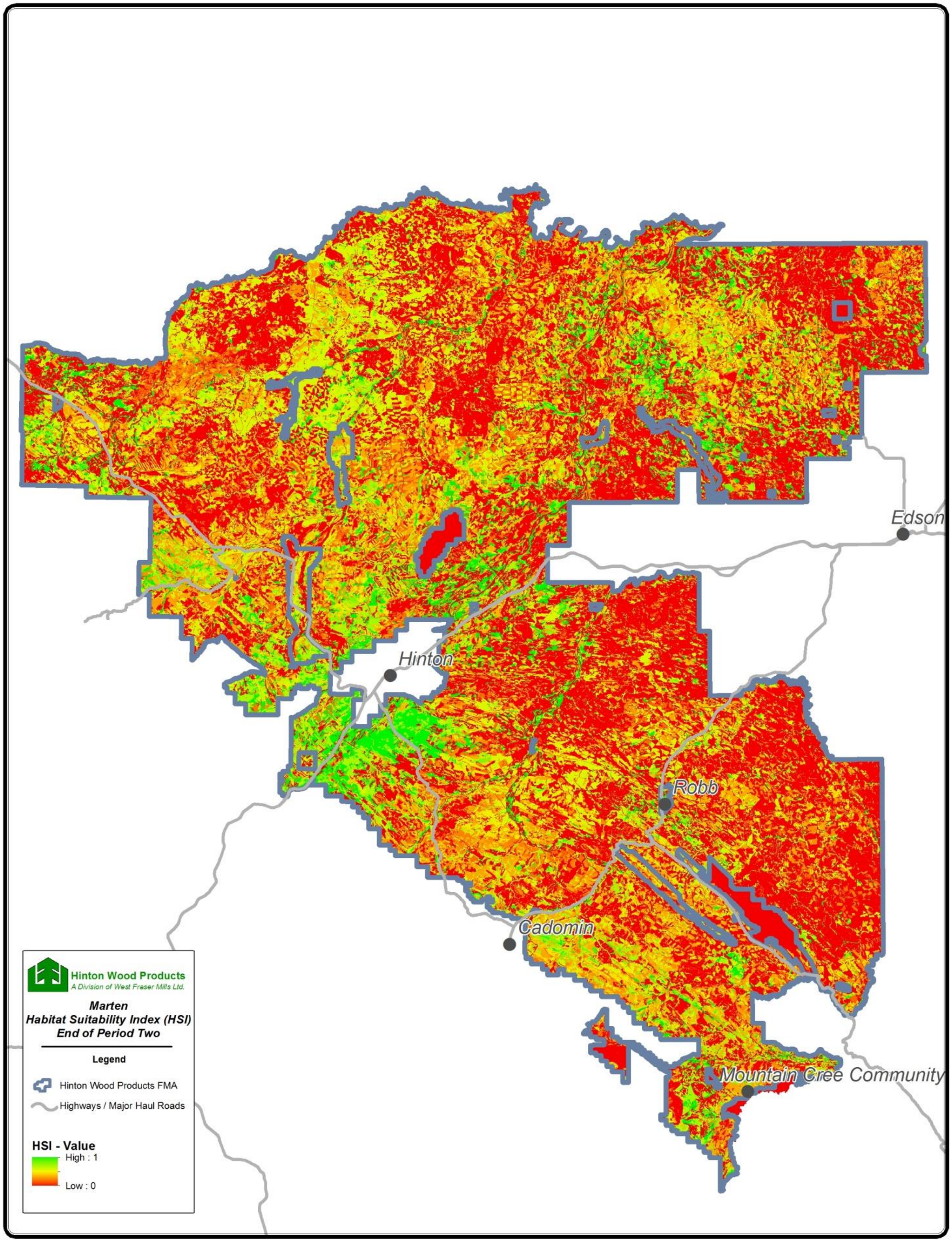

Figure 3 – *Habitat Suitability Index at Year 20*

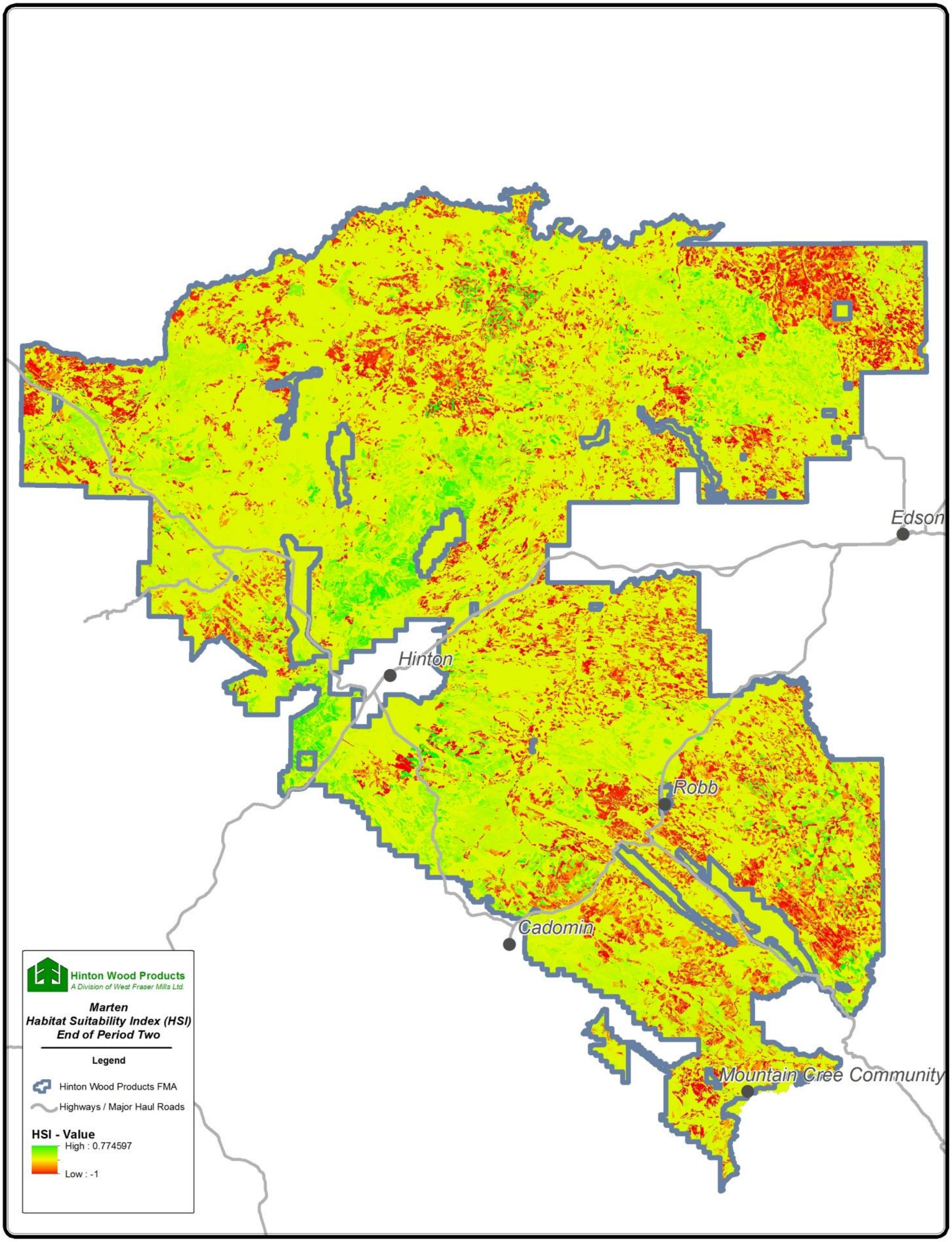

Figure 4 – *Change in Habitat Suitability Index after 20 Year Spatial Harvest Sequence*