THE WESTERN YELLOW-BREASTED CHAT

POPULATION VIABILITY
AND
CRITICAL HABITAT
IN THE
OKANAGAN VALLEY, BC CANADA

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Summary

The Western Yellow-breasted Chat was designated as “Endangered” Species in 2000 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The species at risk act (SARA) prescribes identification and protection of critical habitat for this species. This work contributes to and supplements related recovery and conservation efforts. A comprehensive population and habitat viability analysis has been conducted for the Yellow-breasted Chat (YBCH) in the Okanagan Valley, BC. Metapopulation and individual-based, spatially explicit population models were used to asses demographic viability, minimum viable population size, susceptibility to habitat loss and fragmentation, critical habitat and conservation scenarios for the YBCH population. The results indicate that the YBCH is likely not demographically limited, but endangered by the low population size and by habitat fragmentation. The minimum viable population may be larger than 200 breeding pairs, which far exceeds the currently observed population abundance of 38 breeding pairs in the Okanagan Valley. The low population size combined with fragmentation of habitat in the Okanagan valley may cause a substantial extinction risk of up to about 37 percent over 100 years. About 27 percent of this extinction risk are attributed to the low population size and about 10 percent result from habitat fragmentation. A general habitat configuration analysis revealed that the YBCH population is susceptible to habitat loss and to habitat fragmentation. The effect of habitat fragmentation on the extinction risk may increase by one order of magnitude when the total available habitat supports less than 100 breeding pairs. This predicted threshold is likely attributed to the low dispersal range of the YBCH. Critical habitat has been identified based on simulating the population dynamic of the YBCH on a habitat suitability map. The habitat suitability map is the result of a logical combination of different data layers known to affect the occurrence of the YBCH. The habitat suitability map comprises 900 ha suitable habitat, 244ha of which have been occupied by the YBCH. Habitat patch removal experiments revealed those critical habitat areas, which are most important to the viability of the YBCH population. If the population remains confined to occupied habitat areas, about 180 ha of those areas were identified as critical, based on either a large effect on the extinction risk or on the size of those areas. About 380 ha or 42 percent of all identified suitable habitat may be critical for the viability of the population, based on the assumption that those areas will be occupied in the future. Still, it is unlikely that the YBCH population may survive over an extended period of time without a boost in the population size or continuous immigration from other YBCH populations. Recovery scenarios indicate that a minimum viable population of 250 breeding pairs may survive at a low extinction risk in the south-eastern habitat areas between Oliver and Osoyoos (about 294 ha). Alternatively, restoration and protection of all identified critical habitat in the Okanagan Valley (about 450 ha or 50 percent of the total suitable habitat) could support a viable population of about 250 breeding pairs with an equally low extinction risk. Most important, however, would be to help increasing the currently low population size. If this can be achieved, protecting the critical habitat areas (450 ha) may prevent the species from local extinction in the Okanagan Valley.

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Notice

The results provided in this report are subject to an unknown degree of uncertainty. There is substantial uncertainty in the knowledge of demographic data, such as fecundity, survival and dispersal distances. There is also uncertainty in the habitat suitability models, which may be reflected in an incorrect habitat suitability map. This uncertainty and its propagation over time is partly considered in the demographic and environmental stochasticity of the population model. Due to the stochastic nature of the population models, simulation runs were replicated up to 1000 times and results are averages out of those replicate simulation runs. Absolute numbers should be interpreted with caution. Instead trends and differences between different simulation runs (scenarios) are generally more trustworthy. All information used in this work have been discussed with members of the recovery team and verified as well as substituted from the scientific, peer-reviewed literature. The work therefore represents our best possible educated "guess" based on our current knowledge of the biology, life history and habitat requirements for this species.

1 Yellow-breasted Chat *(Icteria virens)*

1.1 Demography

The demographic characteristics for the Yellow-breasted Chat (YBCH) in the Okanagan Valley have been compiled based on published data from the literature and in collaboration with the Recovery Team, in particular Christine Bishop. See also the following references for life-history information on the YBCH (Ricketts and Ritchison 2000, Booth and Bio 2001, DeSante et al. 2001, Twedt et al. 2001)

Characteristic	Observation	References
Breeding period	mid-May to mid-June	Schadd and Ritchison 1998 Bishop, pers. comm.
Clutch size	3 – 6 eggs, avg. 3.4	Schadd and Ritchison 1998 Bishop, pers. comm.
Broods/year	1	Schadd and Ritchison 1998 Bishop, pers. comm.
Incubation period	11-12 days	Schadd and Ritchison 1998 Bishop, pers. comm.
Fledging period	9 -10 days	Schadd and Ritchison 1998 Bishop, pers. comm.
Maturity	after 1 year	Eckerle and Thompson 2001 Bishop, pers. comm.
Life Span	max: 8 years, avg. unknown	Eckerle and Thompson 2001
Fledging Success	75.38%	Bishop, unpubl. data
Nesting Success	84% (16% loss by nest predation), lit. 65% (35% loss by predation and/or abandonment)	Burhans and Thompson 1999 Bishop, pers. comm.
Nestling Survival	95% ± 1%	Eckerle and Thompson 2001
BC Population Size	34 pairs (Okanagan) (2002) 4 pairs (Similkameen) (2002)	Bishop, unpubl. data
Stage/Age class	juvenile / adult	Bishop, pers. comm.
#fledglings per territory	3.25 ± 0.17 (Kentucky population), lit. 1.04 ± 0.34 (small patches in Missouri), lit. 1.34 ± 0.36 (larger patches in Missouri), lit. 3.06 ± 0.34 (BC)	Thompson & Nolan 1973 Bishop, unpubl. data
Annual Survival	juvenile: 0.3 ± 0.09 (30%) adult: 0.6 ± 0.2 (20%)	estimate based on Thompson & Nolan 1973
Dispersal/Movement	~ 1 km	Bishop, pers. comm.
Average Territory Size	1.24 ha (Southern Indiana) avg. 0.5 - 1 ha	Thompson & Nolan 1973 Bishop, pers. comm.
Habitat Requirements	dense thickets around wood edges in low wet places near streams, pond edges, or swamps, overgrown clearings, early successional stages in forests regeneration, grass-herb-shrub layer, key shrub species for nesting is wild rose and a close secondary species is snowberry.	Sedgwick and Knopf 1987 Robinson and Robinson 1999 Bishop, pers. comm.
Threat	very low population size, sensitive to effects of grazing, urban shoreline development, habitat loss	Sedgwick and Knopf 1987
Sex Ratio	unknown, assume 50%	Thompson & Nolan 1973
Carrying Capacity in the Okanagan Region	400 breeding pairs (estimated)	Bishop, pers. comm.

Table 1: Life history data for the Yellow-breasted Chat

1.2 Population Model

1.2.1 Model Characteristics

Two software programs RAMAS® GIS (Akçakaya and Root 2002) and PATCH (Schumaker 1998) were used to model the population dynamics of the Yellow-breasted Chat. RAMAS® GIS provides a comprehensive set of tools to evaluate the viability of a population or a metapopulation, i.e. a population of populations, of which some may become extinct and re-colonized in isolated habitat fragments. PATCH allows to define and simulate a population model in terms of single individuals, which operate in a spatial, territorial environment. Both software programs allow to analyze the viability of populations and to rank the corresponding relative importance of habitat areas.

1.2.2 Parameter Values

A population model is defined by its conceptual structure (e.g. presence/absence, age classes, individual based) and by its parameter values. Latter must be defined based on the biology and life history of the species of interest.
For the YBCH fecundity rates per adult female have been extracted from a breeding survey in 2002 in the Okanagan Valley, BC, which was conducted by Christine Bishop. Breeding data from all successful nests, which were not abandoned during the breeding stage, are included in the calculation of the fecundity rate (Table 2). For failed nests, data were excluded, because the birds likely attempted another nest (Bishop, pers. comm.).

TERRITORY	#EGGS	#NESTLINGS	#FLEDGLINGS
THE FALLS	4	4	4
CURLEW FIELD	4	4	3
THRONE SOUTH	6	6	5
HAUNTED HOUSE	4	4	4
THRONE NORTH RE-NEST	3	3	3
TRISTAN	4	4	4
SUPERCHAT	3	2	0
FRIENDLY	2	2	2
FLASH	4	4	4
KAYKAITKW	4	4	4
VASEUX RE-NEST	1	1	1
LOWER FAIRVIEW RE-NEST	4	3	3
SMUGGLER	4	4	4
WILDEBEEST	3	3	3
ALICE IN WONDERLAND	3	3	3
BAPTISTE	4	2	2
Average	3.5625	3.3125	3.0625
Standard Error	0.273	0.298	0.322

Table 2: Breeding survey data for the YBCH in the Okanagan region. Data from these successful nests have been used to calculate the fecundity rate per female. (3.06 * 0.5 (sex ratio), adjustment to sex ratio necessary for females only model)

Annual survival rates for the YBCH are unknown. However, estimates are available (see Thompson and Nolan 1973) and range between 0.1 and 0.4 for juveniles and between 0.4 and 0.7 for adult individuals. Experimental simulations (based on the adult fecundity rate per female of 1.53) revealed an overall stable population size over ten years for juvenile survival at 0.3 and adult survival at 0.6, which corresponds to the observed stable population size of the YBCH in the Okanagan region. The estimated survival rates are also in line with observed survival rates for other small passerine birds (see Thompson and Nolan 1973).

The population model is a "female only" model and the results are based on the number of females. Since the sex ratio is assumed to be even and no differences in the survival rates for males and females are known, the number of females is a good indicator for the actual number of breeding pairs.

Parameter	Value/Range	Comments
stage classes	juvenile/adult	Bishop, pers. comm.
juvenile fecundity	0	
adult fecundity (female juveniles per female adult)	1.53 ± (10% stddev.)	Bishop, unpubl. data 2002
juvenile survival	0.30 ± 0.09 (30% stddev.)	estimated after Thompson & Nolan 1973
adult survival	0.60 ± 0.12 (20% stddev.)	estimated after Thompson & Nolan 1973
density dependence	ceiling exp. growth up to carrying capacity of 400 breeding pairs	Bishop, pers. comm.
simulated years	100	
initial population size	38	current known population size in the Okanagan Region
replications	1000	
territory size	1 ha	
dispersal	negative exponential up to 1 km	Bishop, pers. comm.
demographic stochasticity	yes	number of survivors and dispersers (emigrants) to be sampled from binomial distributions, number of young from a Poisson distribution. (important for small populations)
environmental stochasticity	lognormal	statistical distribution (normal or lognormal) to be used in sampling random numbers for vital rates

Table 3: Parameter values for the YBCH population model (RAMAS© GIS)

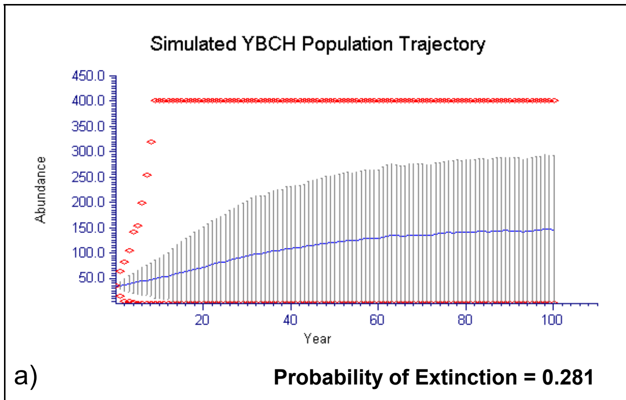
1.2.3 Analysis of the demographic population viability (non-spatial)

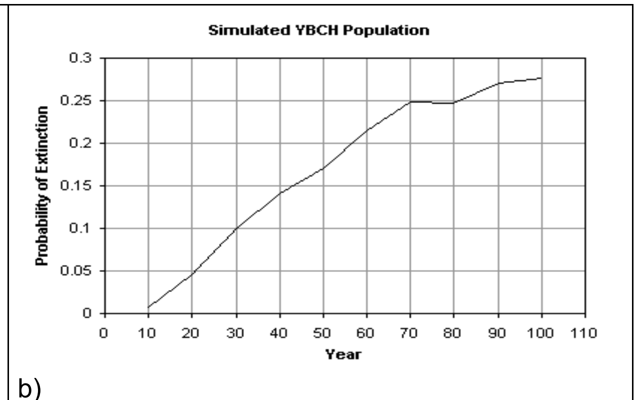
The viability of a non-spatial YBCH population was analyzed based on the model parameter values presented in 1.2.2 using RAMAS© GIS. This non-spatial population model assumes that all breeding females reside in one single habitat patch (a cluster of adjacent territories). No dispersal was required and the population could grow exponentially up to a carrying capacity of 400 individuals. The results of this non-spatial population model identify the demographic viability of the population and will serve as a benchmark for the results of subsequent spatially explicit population and habitat viability analyses. The results are presented in Figure 1.

The graph in Figure 1a shows the average population abundance over the time span of 100 years. The vertical lines indicate the range of the standard deviation and the red trapeziums show the observed maximum and minimum values. The maximum values are cut off at the carrying capacity of 400 individuals. The simulations predict a population growth on average up to 145 female individuals but with a similar sized standard deviation. These fluctuations are the result of the stochastic nature of the model, or in other words, the propagation of uncertainty (in particular the standard deviations around the fecundity and survival rates, see Table 3). The predicted probability of extinction (or extinction risk) is 28 percent. The extinction risk is calculated as the proportion of replicate simulation runs in which the population became extinct. In this case the population went extinct in 281 out of 1000 replicate simulation runs.

The graph in Figure 1b shows the extinction risk as a function of time. Due to the proliferation of uncertainty and the accumulated effects of stochastic events throughout the course of the simulation (and also in nature), the extinction risk increases over time. The results indicate a zero extinction risk for a time span of up to ten years and a 27 percent risk of extinction after 100 years. These numbers result from the actual known initial population size of 38 breeding pairs in the Okanagan Valley and the applied carrying capacity of 400 breeding pairs.

The graph in Figure 1c shows the minimum viable population size (MVP) for an extinction risk of less than 1 percent over different time spans. For example, an initial population size of 150 breeding pairs is required to realize a 99 percent viable population over a time span of 40 years. This initial population of 150 breeding pairs would grow during the 40 years to a final population size of 215 pairs. For a time frame of 80 and 100 years, the initial and final population sizes are almost identical, indicating that the average population size remains stable.





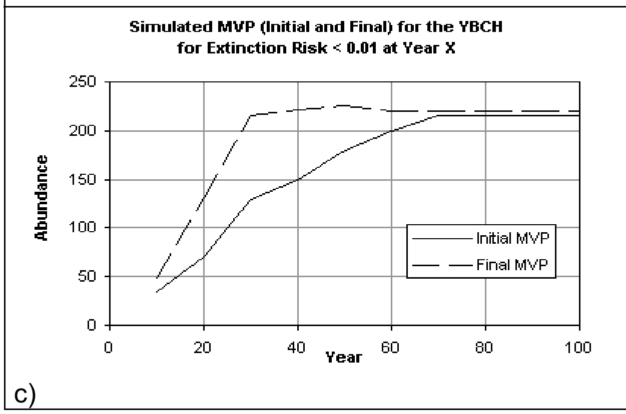


Figure 1:

a) Predicted population (females only) abundance over 100 years (based on initial population size of 24 females and carrying capacity of 80 females);

b) Probability of Extinction over 100 years;

c) Minimum viable population (MVP) size. Solid line shows initial MVP and dashed line shows final MVP.

Predictions from PATCH

Population dynamics for the Yellow-breasted Chat have also been simulated with the individual based, spatially explicit model PATCH. The model parameters reflect those used in RAMAS© GIS. All 400 available territories (carrying capacity) were grouped adjacent to each other into one circular patch of habitat. This setting allows movement between territories only, but does not require movement across non-habitat. It is therefore the closest approximation to a non-spatial setting as used in RAMAS© GIS. The predicted projection of the population abundance over 100 years is shown in Figure 2. The predicted increase in population size exceeds those calculated by RAMAS© GIS.

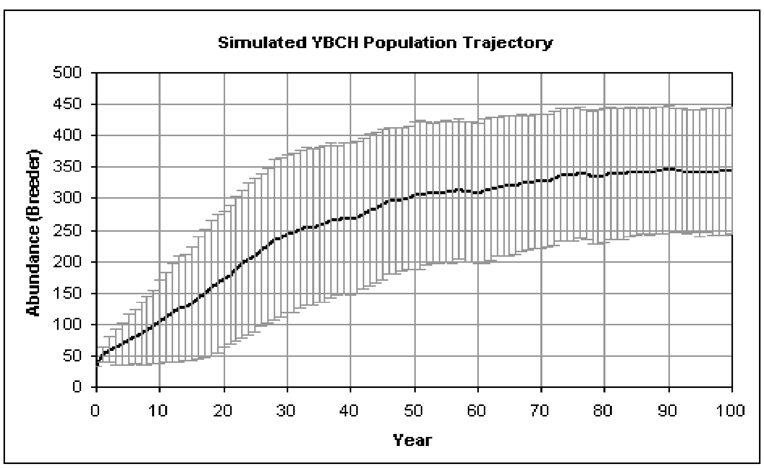


Figure 2: Population abundance for the Yellow-breasted Chat in non-fragmented habitat simulated with PATCH.

1.2.4 Habitat Configuration Analysis

The effects of habitat amount and fragmentation have not been considered in the previous population viability analysis. The amount of habitat necessary to support a viable population can be estimated from the minimum viable population size times the average territory area. This extrapolation is justified and appropriate when all territories are equally accessible to all members of the population. Habitat, however, is distributed in space and territories are often not adjacent to each other. In most situations, habitat is fragmented and its accessibility depends on the movement or dispersal capabilities of a species. Habitat fragmentation and its effect on population viability have become a major area of interest and research in recent conservation ecology. It has been shown in various studies, that the relative importance of habitat fragmentation depends on the actual amount of habitat in a landscape. The following analysis shall help to understand the effects of habitat amount and fragmentation on the viability of the Yellow-breasted Chat based on our current understanding of its population biology.

In order to address this question, 60 simple landscapes have been generated using an algorithm published in Fahrig (1997, 1998), Tischendorf and Fahrig (2000) and Tischendorf (2001). Each landscape consists of 100x100 pixels of 100 meter edge length per pixel. The extent of a landscape is therefore 10 km resulting in an area of 100 square km. The pixel size of 1 ha corresponds roughly to the size of one territory of the Yellow-breasted Chat (see 1.1, Table 1).
The value of each pixel can either be habitat or non-habitat (matrix). The algorithm used for generating the landscapes allows habitat to be distributed across the landscapes in a more or less fragmented way. Some exemplary landscape models are shown in Figure 3. The amount of habitat (or number of 1 ha territories) was varied between 40 and 400 and the fragmentation for each of the habitat levels was varied across 6 levels from low to high. In Figure 3 each row shows from left to right increasingly fragmented distributions of a certain number of 1ha territories (or habitat amount). The numbers to the right of the figures show the actual number of 1ha territories and the degree of fragmentation. Fragmentation was measured using the “effective number of habitat patches (EN)” (whereas patches are adjacent pixels in the model or neighbouring territories in reality). This new measure of fragmentation was recently developed by Jochen Jaeger (Jaeger et al. 2003). EN has the following features: it is an increasing function of the number of patches; it is an increasing function of the similarity of patch sizes; it is conceptually independent of habitat amount; and it is independent of patch shape and dispersion.

On each of the 60 generated landscapes the population model of the YBCH as described in 1.2.1 was executed using RAMAS© GIS. The population was initially distributed across all territories (habitat pixels in the generated landscapes). The carrying capacity was identical to the number of territories and the initial total population size was half the carrying capacity for each landscape. In addition to the non-spatial model described in 1.2.1, individuals were allowed to move within the landscapes. The maximum dispersal distance of the YBCH was estimated to be 1 km. This distance was used as a maximum in a negative exponential function. Probability of extinction was measured for each simulation and subsequently related to the habitat amount (# of 1ha territories) and habitat fragmentation (EN, see above). The results are shown in Figure 4-6.

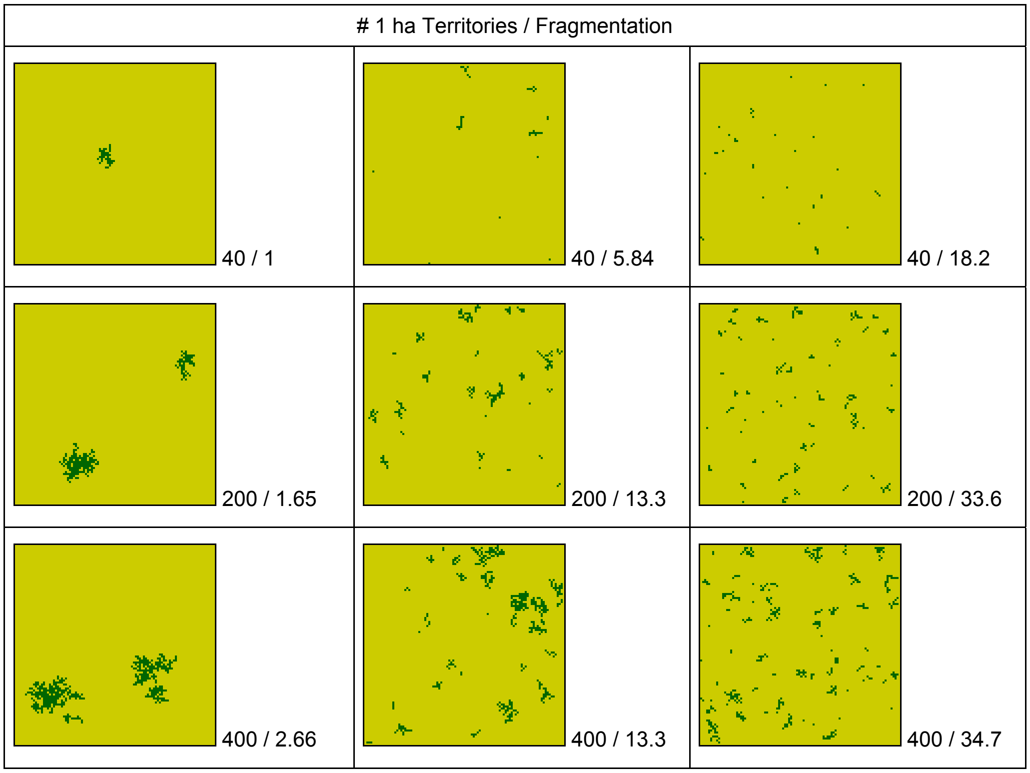


Figure 3: Landscape models used to examine the effect of habitat amount and fragmentation on the probability of extinction for the YBCH. Each row shows 3 (out of actually 6) landscapes containing equal, but increasingly fragmented (left to right), amounts of habitat.

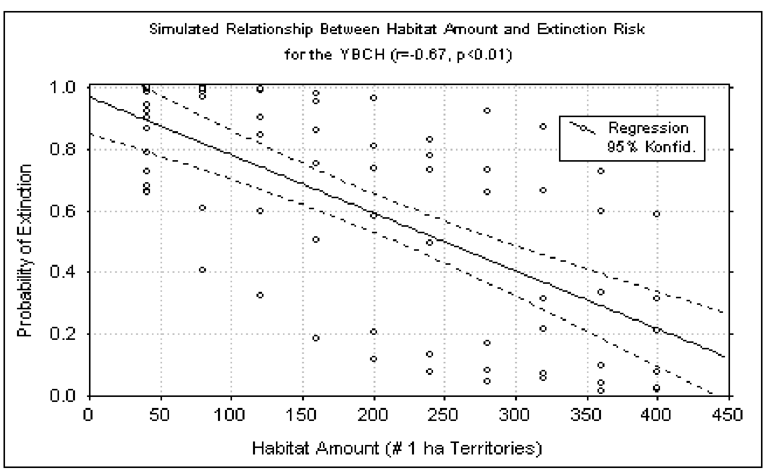


Figure 4: Effect of habitat amount on the probability of extinction. The probability of extinction increases with decreasing habitat amount, but is affected by the spatial distribution of habitat as indicated by the dispersion of the plots.

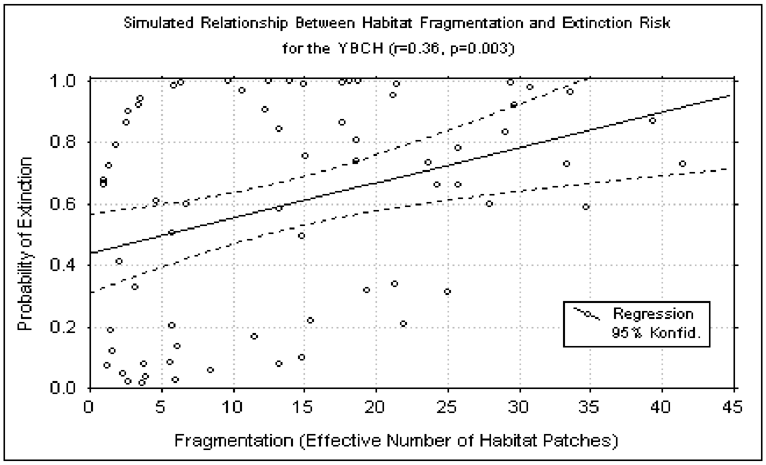


Figure 5: Effect of habitat fragmentation on the probability of extinction. Increasing habitat fragmentation results in overall higher extinction risk, but also depends on the amount of habitat in the landscape.

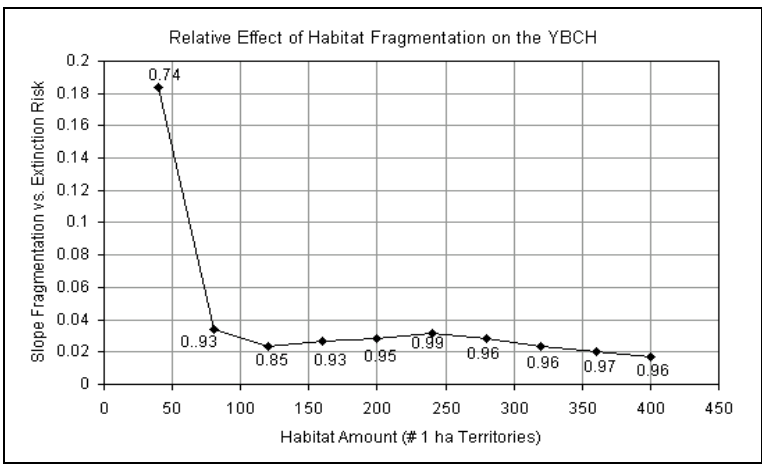


Figure 6: Interaction between habitat fragmentation and habitat amount. The data points are the slopes of the regression lines between habitat fragmentation (EN, see above) and the probability of extinction. The numbers at the plots show the corresponding correlation coefficient r, for the regressions. All regressions were significant at p=0.01. (although some of the relationships are non-linear). The slope of the regression between fragmentation and extinction risk increases dramatically when habitat decreases below 100 1ha territories.

These results indicate that a) habitat loss increases extinction risk, b) habitat fragmentation increases extinction risk and c) the effect of habitat fragmentation on extinction risk increases by one order of magnitude when habitat is reduced to less than 100 territories. The threshold at the habitat amount scale reflects the response of the modelled population biology (and in particular the dispersal distance used in the model) to the generated habitat configurations. Reality is more complex and matrix quality, roads or landscape topography may seriously affect and challenge this relationship. The general pattern, however, is in line with the results of other fragmentation studies.

1.3 Critical Habitat Analysis

1.3.1 Habitat Suitability Map

The critical habitat analysis for the YBCH in the Okanagan valley is based on the habitat suitability map as shown in Figure 8. This map has been produced based on the known habitat preferences of the YBCH. (documentation of the habitat suitability model will be provided by Olson & Olson) The geographical context for the habitat suitability map is shown in Figure 7.

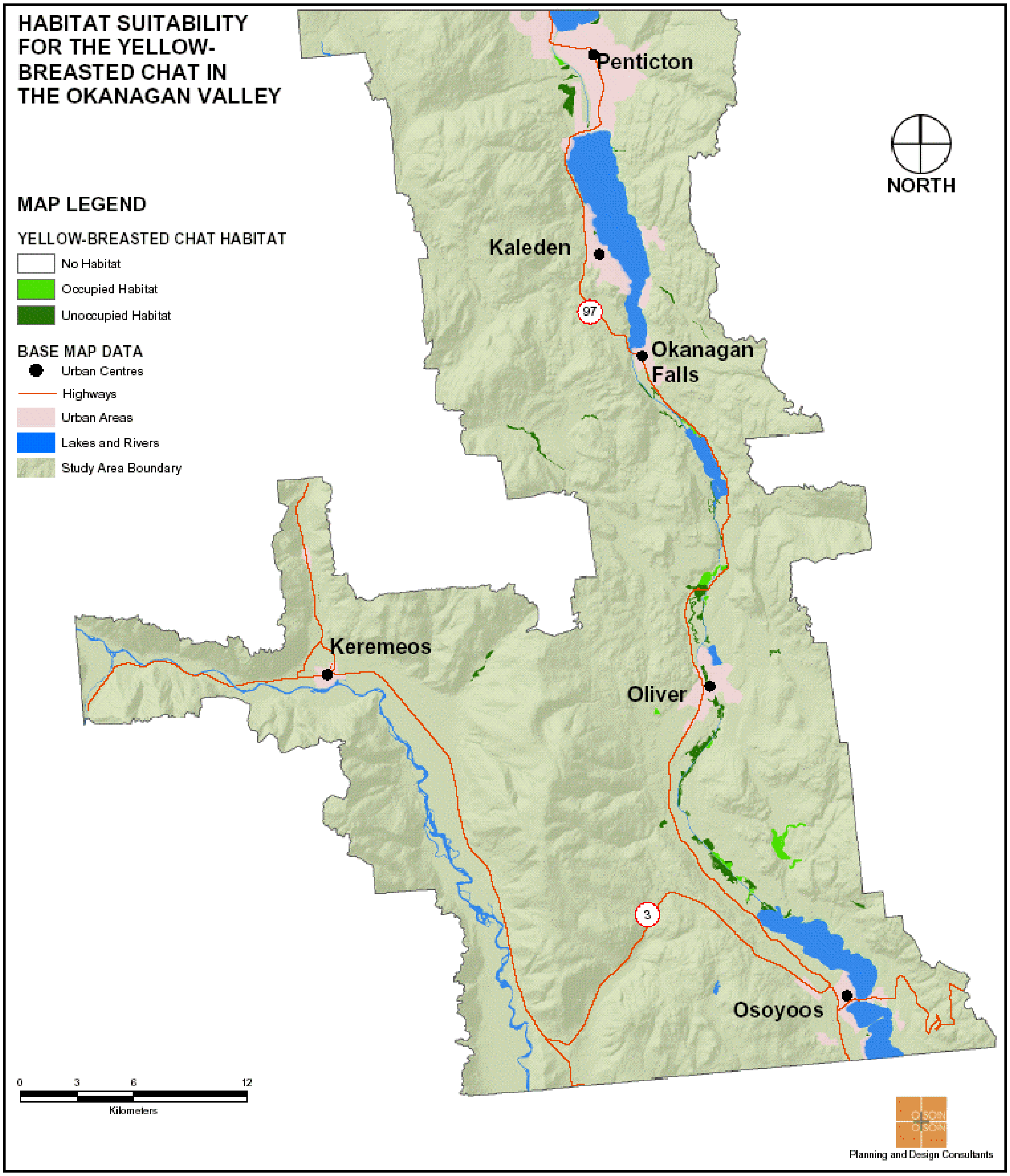


Figure 7: Study area and occurrence range of the YBCH in the Okanagan Valley

The habitat suitability map for the YBCH (Figure 8) contains 3 land cover types: no habitat, occupied habitat and unoccupied habitat. The occupied habitat presents those areas, which were identified as habitat and which were occupied by the YBCH in 2002. The unoccupied habitat shows those areas, which meet the known habitat requirements for the YBCH, but which are currently not occupied by this species.

The habitat suitability map as shown in Figure 8 has the following characteristics: north-south extent = 54.2 km, east-west extent = 29.4 km, pixel size = 25 x 25 m, map size = 2168 x 1177 pixels, total area = 1593.48 km², occupied habitat area = 244 ha, unoccupied habitat area = 668 ha.

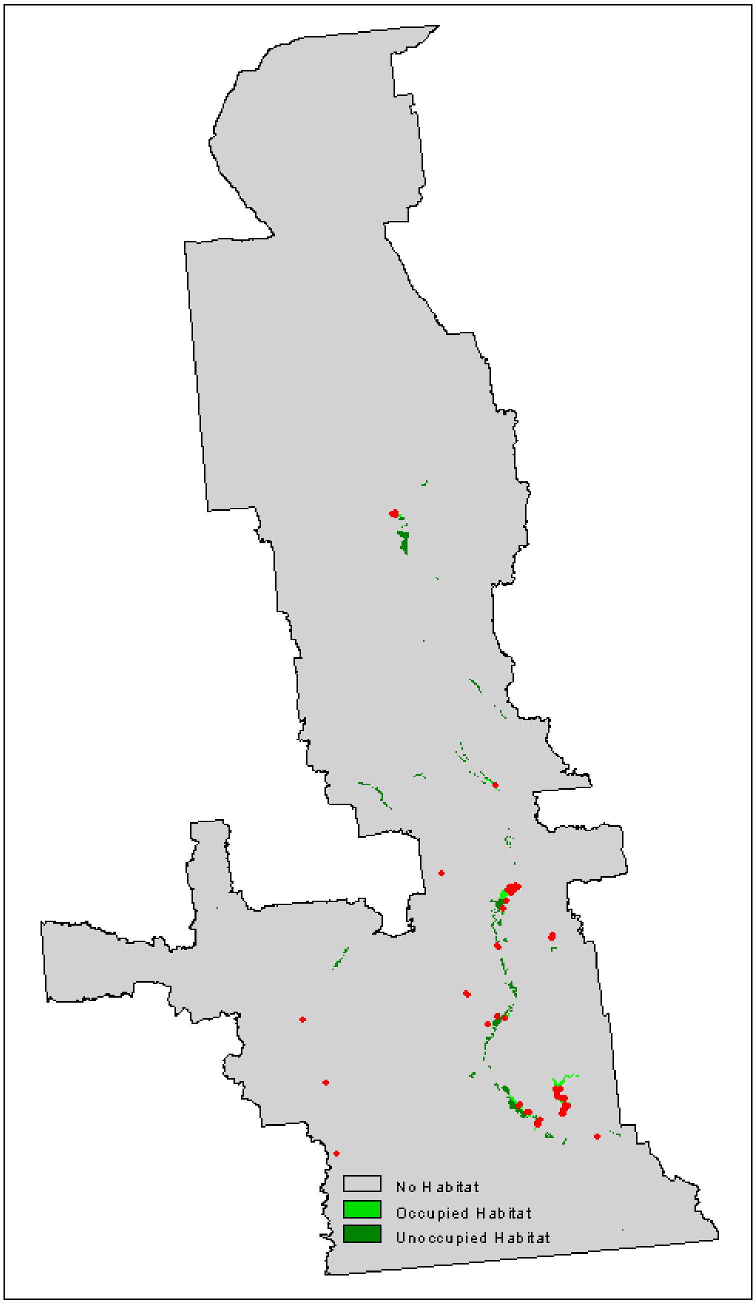


Figure 8: Habitat suitability map for the Yellow-breasted Chat in the Okanagan Valley (29.4 x 54.2 km). The red dots show known breeding sites of the YBCH.

1.3.2 Analysis of the population viability in the Okanagan Valley

The population model as described in section 1.2 has been applied to the habitat suitability map using RAMAS© GIS in order to estimate the extinction risk of the YBCH for the habitat configuration in the Okanagan valley. The simulation procedure corresponds to those used in the habitat configuration analysis (see section 1.2.4). Simulations were conducted on occupied habitat only and on all identified suitable habitat as shown in Figure 8. The results are shown in Figure 9.

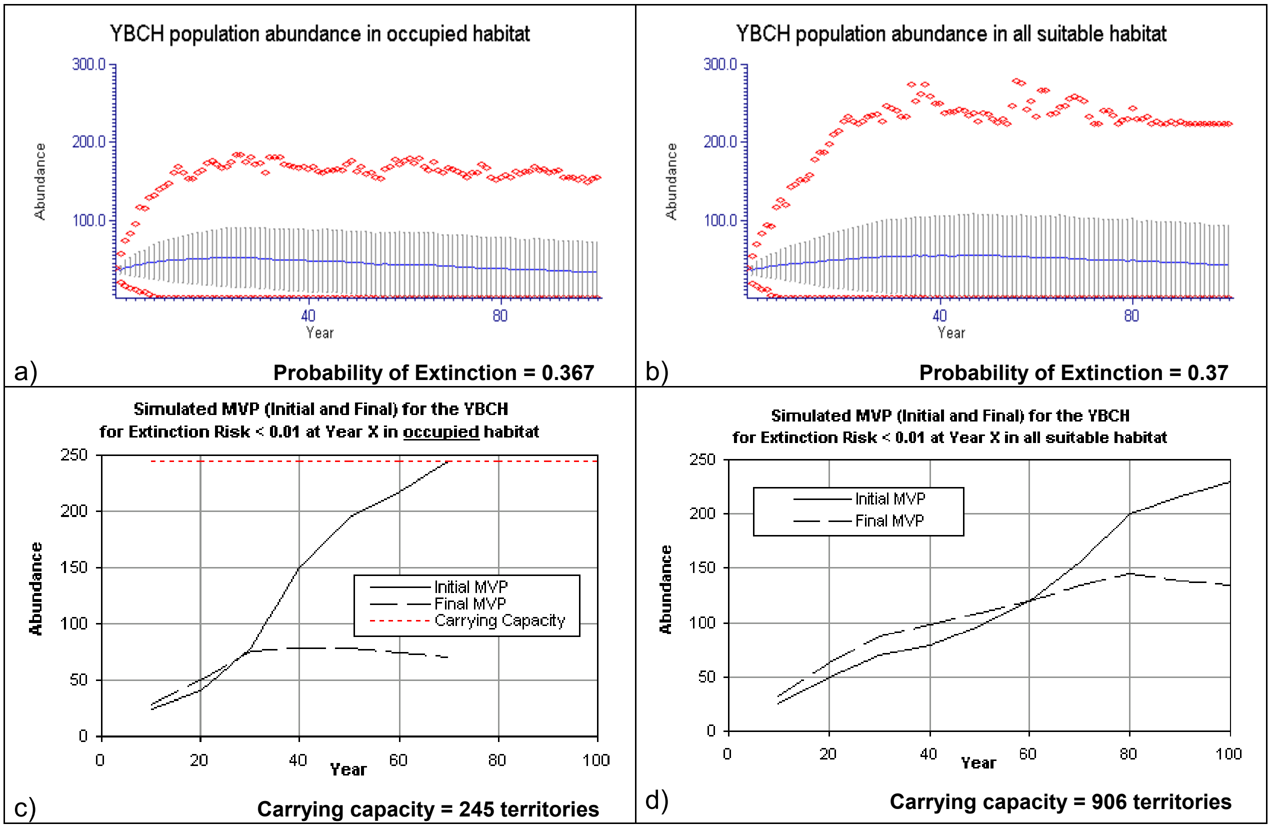


Figure 9: Predicted population abundance and MVP for the YBCH in the Okanagan valley when residing in currently occupied habitat only (left colum) and when using both occupied and unoccupied suitable habitat (right column).

The results of the simulated population dynamics on the habitat suitability map indicate a substantial extinction risk over a time span of 100 years. The extinction risk is about 9 percent higher than predicted for the non-spatial population (compare 0.281 Figure 1a with 0.367 in Figure 9a). The extinction risk is not lower for the population on all (occupied and unoccupied) suitable habitat (Figure 9b). The predicted population abundance for the simulations on all suitable habitat is far below the actual carrying capacity (about 900 ha habitat), which indicates that the YBCH may not be able to utilize all available habitat.

Figures 9c and 9d show the minimum viable population sizes (MVP). The currently occupied suitable habitat may not be enough to support a viable population for more than 70 years. As shown in Figure 9c, the MVP for a time frame longer than 70 years exceeds the actual carrying capacity associated with the occupied suitable habitat. Figure 9c also shows the predicted final population sizes. A final population size smaller than the initial MVP indicates a population decline. For example, the initial MVP for a time frame of 40 years is 150 breeding pairs. A population of this size would decline to about 75 breeding pairs, but still not face a risk of extinction. When all suitable habitat is available for the YBCH, the predicted MVP for a time span of 100 years is about 225 breeding pairs, which is about 25 percent of the total carrying capacity of all suitable habitat (912 ha). Comparison of the results shown in Figures 1c, 9c and 9d indicates that habitat fragmentation and limited landscape connectivity may restrict population growth and affect the viability of the YBCH population. Non-spatial simulation results predict population growth, whereas spatially explicit population models based on the habitat configuration in the Okanagan valley predict population decline. This has effects on the MVP, which may be higher than those predicted in the non-spatial simulation. In fact, the MVP may exceed the carrying capacity of all occupied suitable habitat.

Possible explanations for these predictions are the limited movement capability (~1km) of the YBCH combined with the high degree of fragmentation and the north-south dispersion of the habitat patches over a distance of 50 km. Individuals still may colonize new habitat when returning from their wintering grounds, which may compensate for the low local movement capability. However, the site fidelity of adult individuals has been estimated as high, which may draw returning migrants to occupied habitat and hinder the colonization of potential suitable habitat.

Fragmentation and north-south dispersion of habitat seem to be the main factors for the predicted extinction risk. As shown below (Figure 11) the maximum occupied habitat patch size is 100 ha while most other patches are smaller than 10 ha. Considering the results of the habitat configuration analysis (Figure 6 above), the YBCH populations may face a significant fragmentation effect when habitat amount becomes smaller than 100 territories. While such exact numbers should be interpreted with caution, habitat fragmentation should be regarded as a serious threat to the viability of the YBCH population.

1.3.3 Source – Sink habitat

The population model as described in 1.2 was applied to the habitat suitability map as shown in Figure 8 using the spatially explicit population model PATCH. In a first step, occupied habitat was extracted from the habitat suitability map and simulations were conducted on occupied habitat only. In a second step, simulations were conducted on all occupied and unoccupied habitat. The breeding females of the initial populations were seeded according to the current known occupied territories. Reproduction was restricted to habitat area, whereas movement could occur in non-habitat. The demographic rates for the model are listed in Table 3. Individuals could move between 1 and 10 territories, which corresponds to the observed movement/dispersal distance of about 1 km. Moving individuals chose the closest available territory while moving. (Note, patch allows to set the movement mode to 'random walk', 'optimal' and 'closest') Since no data are available for the territory selection of the YBCH, we assume that individuals will chose the closest available territory while moving. Random walk is unlikely. A sensitivity analysis between the 'optimal' and 'closest' movement mode showed slight but insignificant differences in the model output.
Side fidelity for adult individuals was set to medium out of the options 'low', 'medium' and 'high'. Simulations were conducted for 100 time steps (years) and replicated 100 times. Patch records occupancy rates, emigration and immigration rates into patches among other demographic measures. The results are illustrated in Figure 10.
The green areas indicate higher occupancy and net emigration rates, whereas yellow or red areas indicate lower rates. The maps in Figure 10 show that larger patches, which are also close to each other have the highest occupancy rates and serve as sources for smaller or peripheral territories. Those areas should therefore be regarded as most critical for the viability of the YBCH population.

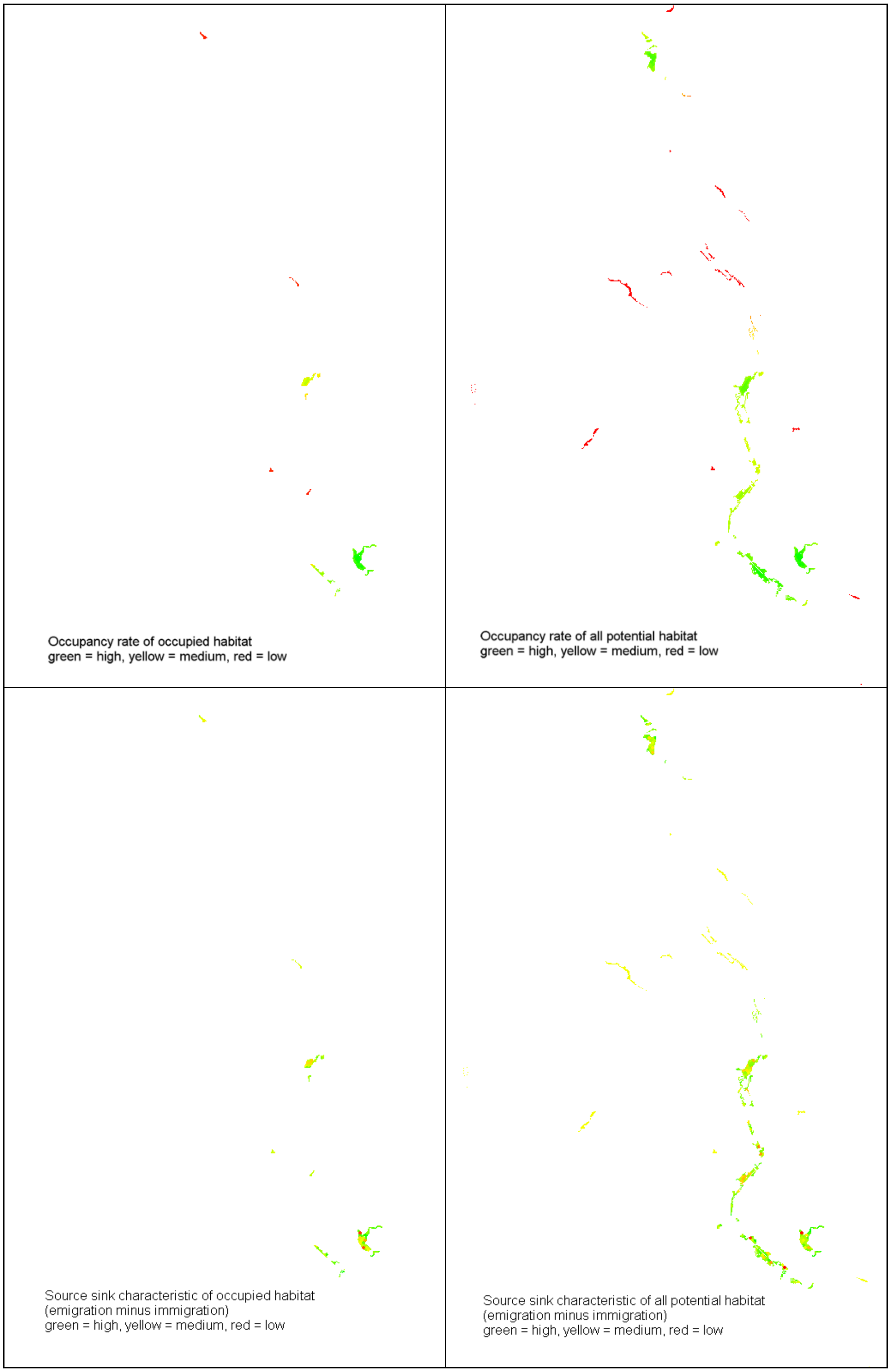
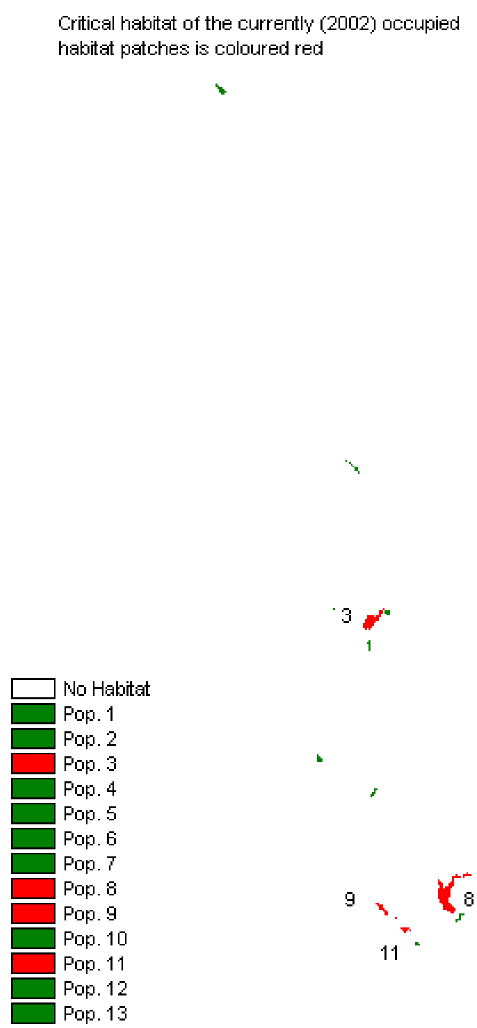


Figure 10: Occupancy rates and source – sink characteristics for occupied habitat only (left column) and all identified suitable habitat (right column)

1.3.4 Critical Habitat

In order to identify the most critical habitat patches (in addition to the source-sink ranking as shown in Figure 10), a patch-removal experiment was conducted. (Patches are clusters of orthogonally and diagonally adjacent pixels). The population dynamics of the YBCH were simulated on the habitat suitability map using RAMAS© GIS. Several replicate simulation runs were conducted while each time one patch was removed. The difference in the risk of extinction resulting from simulations on all habitat patches and those from simulations where one patch was removed indicate the relative importance of the habitat patch for the extinction probability. In the resulting critical habitat maps all those patches are categorized as critical (and marked in red colour), which reduce the extinction risk by more than 2 percent. Note that this categorization is arbitrary and for the purpose of highlighting the most critical habitat patches. Criticality is actually directly proportional to the relative importance of a patch to the extinction risk and to its size. This experiment was conducted on the occupied habitat map only (Figure 11) and on the entire habitat suitability map (Figure 12). The population (38 individuals) was seeded into the habitat patches according to the occupied breeding sites in 2002.



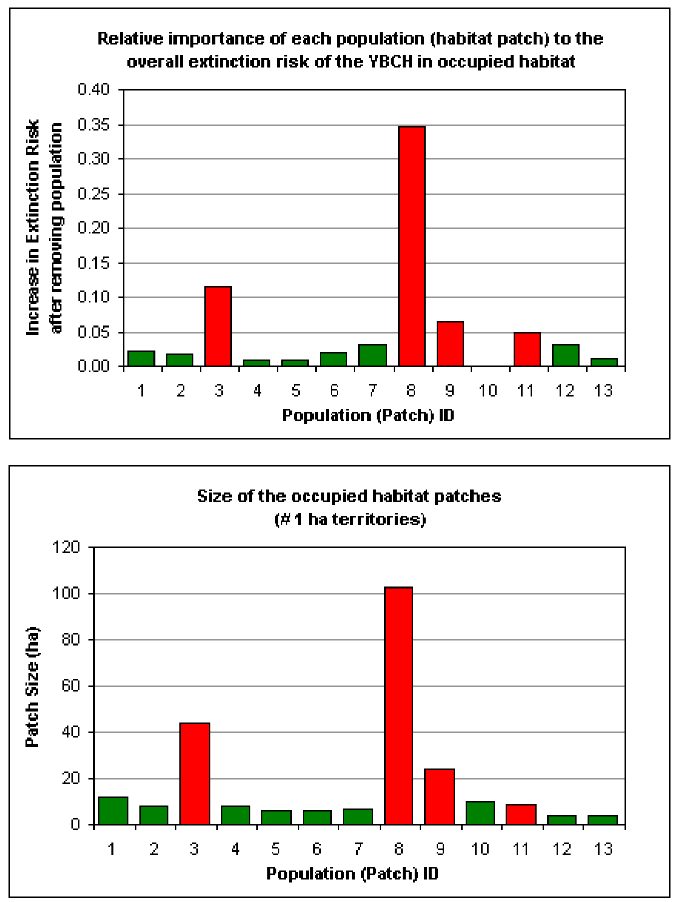
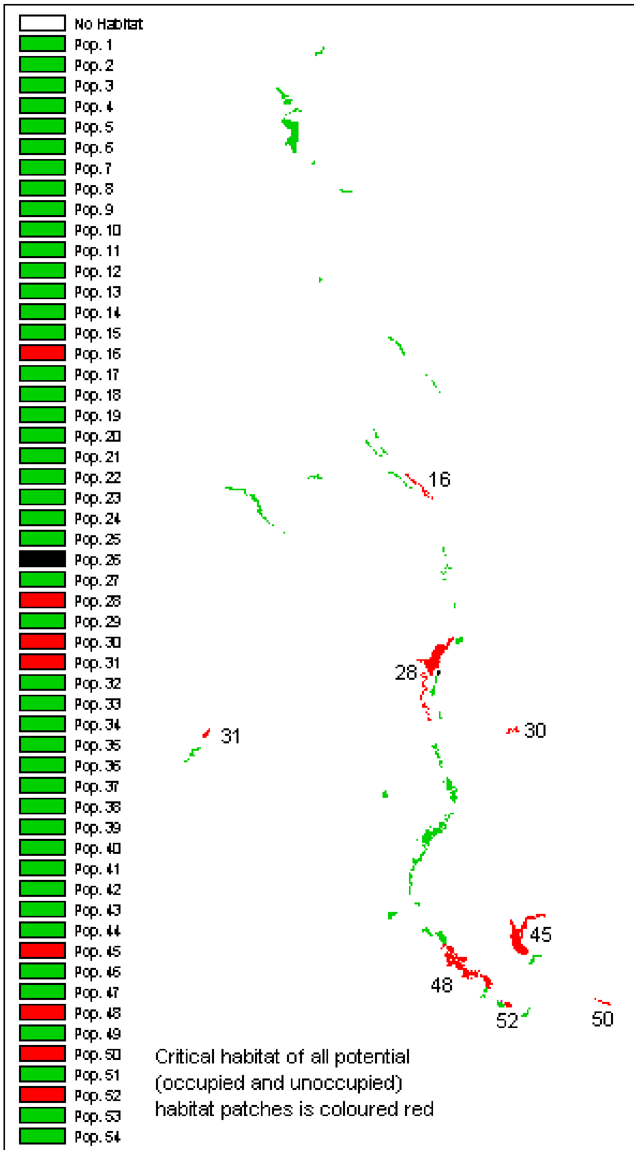


Figure 11: Relative importance of <u>occupied</u> habitat patches to the extinction risk of the YBCH populations. Critical habitat patches are marked in red colours in the critical habitat map (left), their relative importance to the extinction risk is shown in the upper graph. Habitat patch sizes are shown in the lower graph.

The results indicate that the largest patches have the strongest effect on the extinction risk and must therefore be regarded as critical habitat. However, vicinity to other patches (isolation) may also affect the relative importance of a habitat patch. For example, patch (pop) 28 in Figure 12 is one of the largest habitat patches, but its relative importance to the overall extinction risk is comparatively small. This may be attributed to its isolation as one can see in the critical habitat map.

Removing habitat may also decrease the extinction risk as indicated by the result shown in Figure 12. After removing patch (pop) 26, the extinction risk was reduced by 12 percent. Simulations have been repeated many times to exclude stochastic effects, but the results remained consistent. While this effect should not be used to argue for removing habitat, it indicates a strong source-sink or density dependent effect. It is likely that the small patch 26 draws many immigrants from its large neighbour (patch 28). These immigrants may not all reproduce because of the low carrying capacity of patch 26. In this way, patch 26 represents a sink drawing away potential adult individuals from a more valuable resource. Again, this may just be an artefact of the population model and must not necessarily hold true in reality.



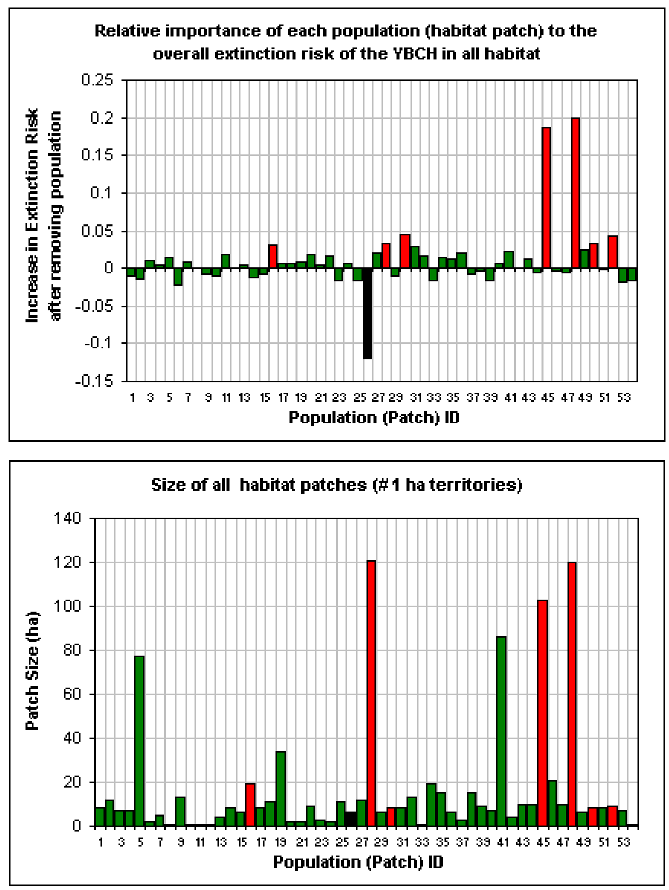


Figure 12: Relative importance of <u>all</u> habitat patches to the extinction risk of the YBCH populations. Critical habitat patches are marked in red colours in the critical habitat map (left), their relative importance to the extinction risk is shown in the upper graph. Habitat patch sizes are shown in the lower graph.

Overall, habitat patches, which changed the extinction risk by more than 5 percent (colour coded in Figure 11 and 12) make up 74 percent of the occupied habitat and 42 percent of the entire suitable habitat. This indicates, that most suitable habitat, which is not currently occupied may not be accessible to the population and may therefore not effectively contribute to reduce the extinction risk of the YBCH. This is likely caused be the large degree of habitat fragmentation and habitat dispersion.

1.4 Conservation Scenarios

1.4.1 Habitat restoration and protection between Oliver and Osoyoos

The critical habitat analysis revealed critical habitat in the south-eastern region of the YBCH distribution. In particular patches (populations) 45, 48, 52, and 50 in Figure 12 seem to be most critical for the viability of the YBCH population. The total carrying capacity of those areas may comprise about 294 territories (294 ha) and exceeds the predicted MVP's for the YBCH (see Figure 9). One potential scenario would be to prioritize habitat restoration and protection in those areas. In order to estimate the potential success of this conservation scenario, the population dynamics of the YBCH have been simulated exclusively on those habitat areas. A population of 250 individuals was seeded in those habitat patches (Figure 13). This is different from the population seeding in the critical habitat analysis (section 1.3.4), in which only 38 individuals were seeded in the occupied habitat areas. The results of this simulation experiment indicate a low extinction probability of about 4 percent together with a steady population decline. Reducing habitat fragmentation in this area may help to support a viable population, presumed that the a large initial population close to the MVP can be established in this area.

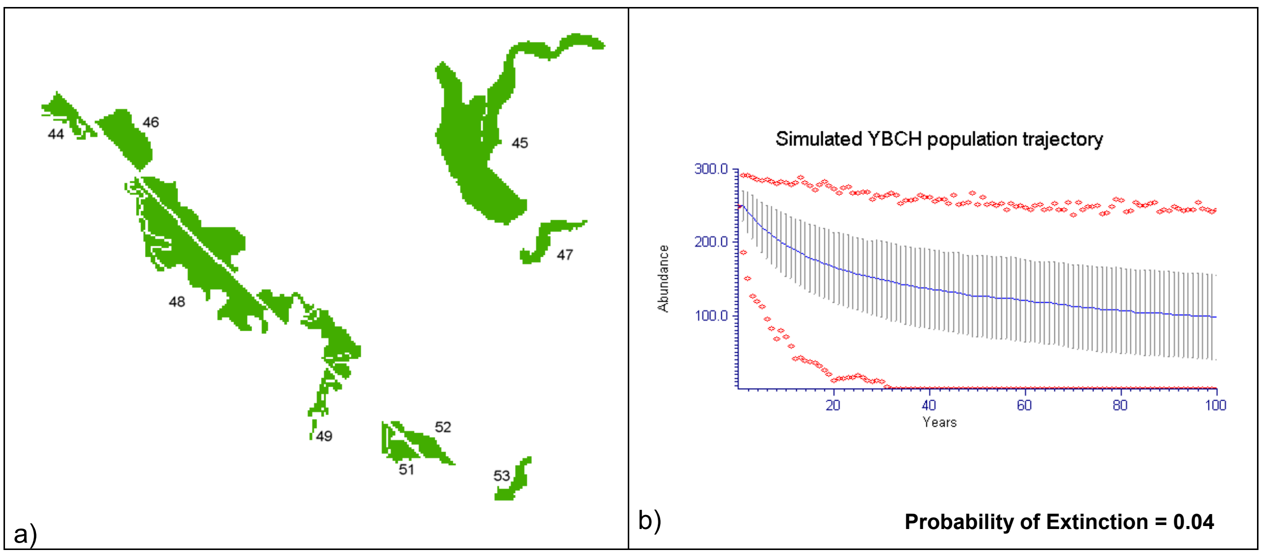
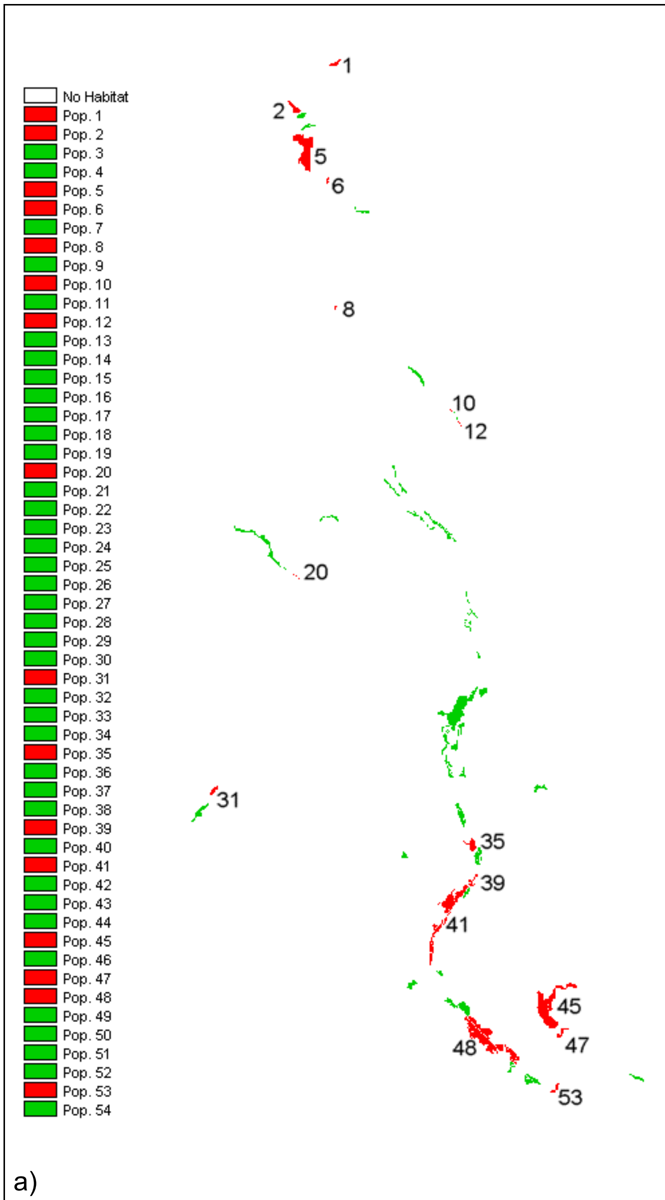


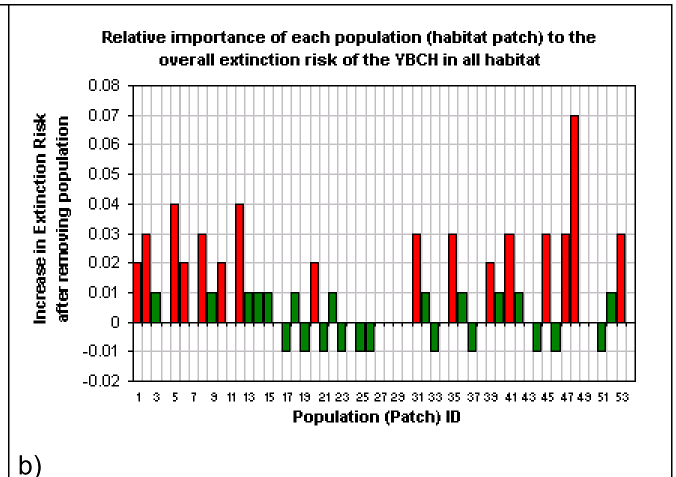
Figure 13: Population viability on selected critical habitat (patch numbers correspond with those of Figure 12)

1.4.2 Restoration and protection of all critical habitat

Prioritising restoration and protection of all identified critical habitat may also be a promising conservation scenario for the YBCH. The critical habitat analysis in section 1.3.4 was based on the initial distribution of 38 individuals in occupied habitat. Consequently, those patches, which were initially occupied had a strong effect on the reduction of the extinction risk. In order to avoid biases based on currently occupied habitat, critical habitat was re-analysed based on a uniform distribution of 250 individuals across all

identified suitable habitat. This scenario weights each patch equally based on its size and location within the habitat configuration. The results of this scenario are shown in Figure 14.
In contrast to the critical habitat map as shown in Figure 12, more patches, in particular in the northern range of the YBCH distribution were identified as critical. The total area of all critical habitat patches in Figure 14 is 462 ha, about half the size of all identified suitable habitat.





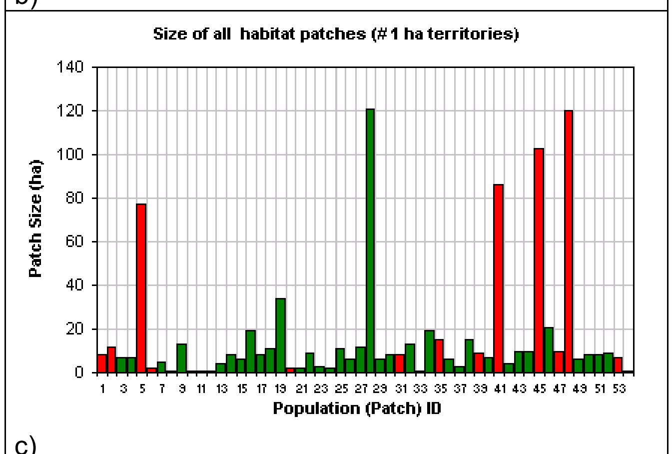


Figure 14: Relative importance of all habitat patches to the extinction risk of the YBCH populations based on a uniformly distributed population of 250 individuals. a) Most critical habitat patches are marked in red colours in the critical habitat map. b) Relative importance of the habitat patches to the extinction risk. c) Sizes of the habitat patches.

The results of simulating the population dynamics of the YBCH exclusively on the critical habitat patches as identified in Figure 14 are shown in Figure 15. The predicted population abundance indicates a slight population decline over 100 years and a risk of extinction of about 1 percent. The maximum recorded population abundances are close to the actual carrying capacity of 462 territories, which indicates that this habitat configuration may allow the YBCH to utilize most of the available habitat.
This scenario shows, that about 50 percent of the identified suitable habitat may be sufficient to support a viable YBCH population in the Okanagan valley. The success of this scenario implies, that those critical

habitat areas are restored and conserved and that an initial viable population of more than 200 breeding pairs can be established in this region.

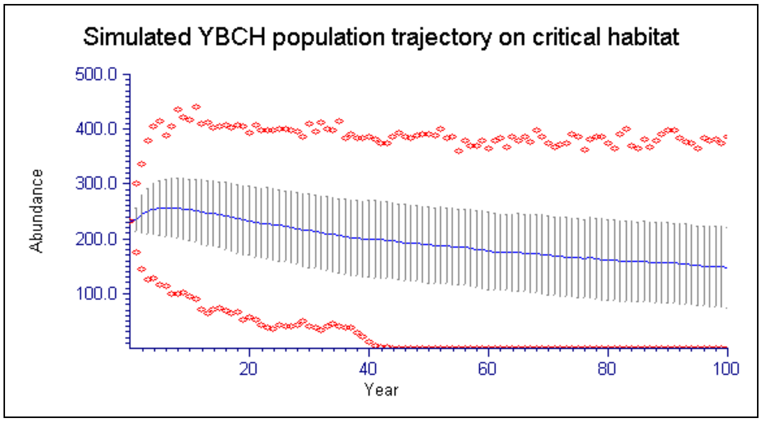


Figure 15: Predicted population abundance for the YBCH on critical habitat as identified in Figure 14. Associated extinction risk is 0.014.

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Tables

Figures