8 OPTIMIZATION OF THE CLIMAX LANDSCAPE REGION

Landscape optimization was restricted to a highly disturbed region within the entire study area for several reasons. First, the dimension of the entire study area requires computational efforts, which could not have been accomplished with the computational resources and time frame of this project. Second, the study area itself is characterized by large regions of natural landcover, mostly grassland, which presents not much potential for improvement with respect to habitat suitability for native species. We therefore decided to apply our suggested optimization approach to a smaller and highly disturbed region within the study area.

The Climax Landscape Region is located central to the study area and characterized by a comparatively low amount of natural landcover types. The current conditions of the Climax Landscape Region are shown in Map 8.1 and the proportions of landcover types are tabulated in Table 8.1.

Table 8.1 Amount and proportion of landcover types in current Climax Landscape Region – baseline

	Cover	
Class	**Area (ha)**	**% of Landscape Region**
Cropland	273,107	45.31
Grassland	246,798	40.90
Wetland	15,295	2.67
Trees	391	0.06
Shrubs	9,158	1.52
Unvegetated/Badlands	14,530	2.40
Water	14,870	2.50
Settled/Roads	6,045	1.00
Pasture	16,579	2.75
Hay/Forage	4,882	0.80

The Climax Landscape Region as chosen for the optimization encompasses an area of approximately 6788 km^2 extending 117 km from west to east and 58 km from north to south. More than 50 percent of this region are used for agricultural production, and crop production accounts for more than 90 percent of total agricultural land-use. This situation results in a limited and likely insufficient availability of suitable habitat for most of the native species. Therefore, this region presents potential for increasing habitat amount, but also for improving the quality of existing habitat and therefore biodiversity in general.

This chapter demonstrates, how one heuristic optimization technique, a genetic algorithm, can be used to identify a potential biodiversity target or reference condition, against which land-use changes, and in particular changes in agricultural land-use practices, can be evaluated. Our approach will reveal the best possible configuration and composition of landcover types with respect to habitat suitability and abundance for 4 selected target species. This “optimal landscape” is tailored to the needs of 4 representative target species under consideration of socio-economic constraints.

Different species and associated habitat suitability models as well as different constraints to land-use changes would have produced different results. Also, as always, more accurate data and better land-use classifications would have allowed to consider more specific habitat associations and perhaps provided for more "accurate" results. The presented optimization approach, however, and its particular potential to identify biodiversity targets in agricultural or "working" landscapes based on surrogate measures is of key interest within the context of this project.

8.1 Optimization approach

Based on our initial evaluation of potential optimization techniques (see 2.5), we decided to use Genetic Algorithms to optimize the Climax Landscape Region. We compared test runs based on Simulated Annealing and Genetic Algorithms and found the latter approach superior in terms of convergence and finding the global vs. local optimal solutions. We used the Genetic Algorithm Library "galib" as introduced in 2.5.6.

8.1.1 Land-use changes

Any landscape optimization is based on stochastic simulated landscape changes, whereas each newly simulated landscape is evaluated and either rejected or approved for further changes. Such landscape changes must be applied to appropriate spatial units, such as cells of a raster-based landscape model, or polygons/patches of a vector-based landscape representation. The initial landcover map was modified as follows to allow for appropriate polygons as spatial units for simulation.

First, in order to use appropriate polygons, the initial landcover map was intersected with a quarter section map. The resulting polygons were delineated by either landcover boundaries or quarter section boundaries. Land-use changes were now applied to polygons not larger than single quarter sections. This unit of potential change seems an appropriate compromise for the purpose of evaluating implications of large-scale land-use changes under consideration of the primary administrative unit in this landscape.

Second, it was furthermore necessary to create new polygons to accommodate for the creation of buffers around wetlands and water bodies. We therefore created buffer polygons of 120 m width along all boundaries between wetland or water and cropland, pasture, hay/forage landcover types. These buffer polygons could then be changed individually during simulation.

Third, areas with a high irrigation potential were excluded from the optimization. This was achieved by clipping the landcover map with a categorical irritation map and excluding all areas with a CLI (irrigation value) lower than 3. The CLI Map is shown in Map 8.4.

To summarize, the initial landcover map was intersected with quarter sections, enhanced with buffer polygons around wetland and water bodies and areas with high irrigation potential were excluded from the optimization. These enhancements are one crucial and important step toward achieving realistic optimization results. This transformed map resulted in about 12,000 changeable polygons for the Climax Landscape Region, encompassing about 39 percent of the entire area. Therefore, simulated landscape changes were restricted to those 39 percent of the entire Climax Landscape Region.

Transition Rules

The landcover types of the 12,000 changeable polygons were stochastically changed during the course of the landscape optimization based on the following landcover type transition rules.

a. A cropland polygon could be transformed into grassland, pasture or hay/forage
b. A transformed grassland polygon could be changed back into cropland, pasture or hay/forage
c. A pasture polygon could be transformed into grassland, cropland or hay/forage
d. A hay/forage polygon could be transformed into grassland, pasture or cropland

e. A cropland buffer polygon around water or wetland could be transformed into shrub. It was assumed that shrubs would grow in these buffer areas if the land was abandoned.
f. A pasture buffer polygon around water or wetland could be transformed into shrub.
g. A hay/forage buffer polygon around water or wetland could be transformed into shrub.
h. A transformed shrub buffer polygon could be changed back to cropland buffer, pasture buffer, hay/forage buffer or grassland.

Constraints

Landscape changes or polygon transformations were restricted to cropland and created buffer polygons around wetland and water bodies. Changes were furthermore restricted to areas with low irrigation potential. A final constraint ensured that at least 22 percent of the Climax Landscape Region, or about 150,000 ha remained cropland throughout the course of optimization.

These constraints reflect socio-economic considerations and ensure that the optimized landscape still provides sufficient area for agricultural land-use. Again, these constraints have been chosen quite arbitrarily for the sole purpose of demonstrating the landscape optimization approach. The optimized landscape will therefore represent the best possible compromise between human land-use and habitat for the 4 selected target species. Different constraints would produce a different result, but the general approach would not change.

In summary, this section described data preparation, transition rules and constraints in preparation for the landscape simulations. It should be noted that some landcover types were entirely excluded and therefore not changed throughout the landscape optimization. Existing Water, Wetland, Grassland, Badlands, Shrubs, Trees and Settled areas were not changed and are therefore still present and unchanged in the optimized landscape.

8.1.2 Target Species

The following 4 target species out of the 13 selected surrogate species (see 6.2.4) were chosen as habitat suitability indicators for the landscape optimization.

- **Grey copper (*Lycaena dione*)**
- **Loggerhead shrike (*Lanius ludovicianus excubitorides*)**
- **Northern pintail (*Anas acuta*)**
- **Swift fox (*Vulpes velox*)**

These species represent 3 taxonomic groups and home range sizes from about 6 ha to 1080 ha. Therefore landscape optimization would be governed by improving habitat suitability at small and large spatial scales. We used the same habitat suitability models as outlined in sections 6.2.4. The habitat requirements for each target species are summarized as follows:

The Grey copper is a butterfly with a home range of about 6 ha. Its habitat requires wetland and hay/forage. Grey copper adults are known to nectar at alfalfa and clover plants and the larvae feed primarily on dock (Rumex spp.) that grows in wet meadows. The Grey copper would therefore benefit from hay/forage landcover types in the vicinity of wetlands. The transition rules as outlined in 8.1.1 allow for conversion of cropland to hay/forage and should therefore provide for improvements of grey copper habitat suitability.

The Loggerhead shrike is a unique songbird and predator with a home range of about 64 ha. Its habitat comprises shrubs and grassland, preferably on flat land. Habitat suitability is therefore based on slope as well as the proportion of grassland and shrubs within its home range. The Loggerhead shrike would benefit from adding shrub near grassland, preferably on plane areas. The transition rules allow for adding shrub near water or wetlands and should therefore result in landscapes with improved habitat.

The Northern pintail is a migratory dug with a home range of about 650 ha. Northern pintail habitat comprises wetland and grassland within its home range and requires wetlands in close vicinity. Conversion from cropland to grassland in particular near wetlands should improve and add more habitat for this species.

The Swift fox's home range of 1080 ha is the largest of all 4 target species. Swift fox habitat is mostly comprised of grassland, preferably on even ground. Habitat suitability is therefore determined by the amount of grassland within its home range and slope. The swift fox would benefit directly from converting cropland to grassland. Optimization should therefore improve and extend current habitat.

Overall, the 4 selected target species are sensitive to those potential land-use changes as outlined in 8.1.1 and should benefit from landscape optimization. All species, except for the Grey copper, directly depend on grassland and will benefit from adding more grassland to the Climax Landscape Region. Converting cropland to grassland is not directly a desired change in agricultural land-use practices, because it prohibits further agricultural use in those converted areas. The Grey copper, however, would directly benefit from adding more Hay/Forage fields near wetlands. This is the only species, which directly depends on agricultural land-use and would actually benefit from converting grassland into hay/forage fields. Consequently, the 4 species together have conflicting habitat requirements at different spatial scales. The optimal landscape will therefore represent a compromise not just between habitat and agricultural land-use, but also between these partially conflicting habitat requirements.

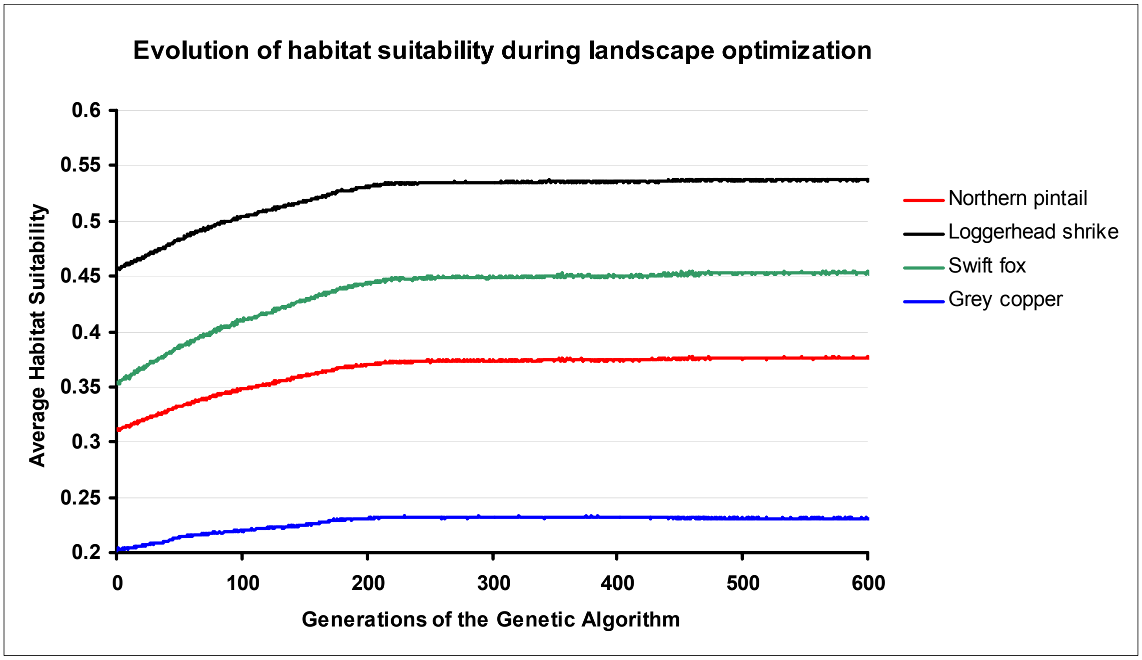
8.2 Impact of Landscape Optimization

The impact of landscape optimization was evaluated quantitatively by calculating the average habitat suitability index for each species for each simulated landscape. The average was calculated across habitat suitability values of all cells in the habitat suitability maps. This average habitat suitability index therefore represents the "global" or overall suitability of a certain landscape to a certain species. It is a measure of quality rather then abundance, because a landscape with lots of marginally suitable habitat may reveal a similar average habitat suitability index compared to a landscape with few areas of high quality habitat. Landscape optimization was governed by and tried to increase the sum of the 4 average habitat suitability indices (for each of the 4 target species).

Another measure for evaluating the impact of landscape optimization was the target species' habitat abundance. Deriving and delineating habitat abundance from a habitat suitability map requires to set a habitat suitability index threshold above which a cell or polygon is considered habitat. Habitat suitability indices ranged from 0 to 1. All cells with a habitat suitability index value greater than 0.5 were considered habitat and included in the habitat abundance evaluation.

Overall, landscape optimization improved habitat suitability and habitat abundance/amount for all 4 target species. Figure 8.1 shows the evolution of average habitat suitability for each target species during the course of optimization. It can be seen that average habitat suitability indices approached a ceiling during the first 200 generations and that the algorithm converged early toward maxima. It is therefore almost certain, that the heuristic search algorithm evolved the landscape toward the best possible solution, i.e. a landscape with maximum habitat suitability for all 4 target species under consideration of the socio-economic constraints.

Figure 8.1 Evolution of target species average habitat suitability

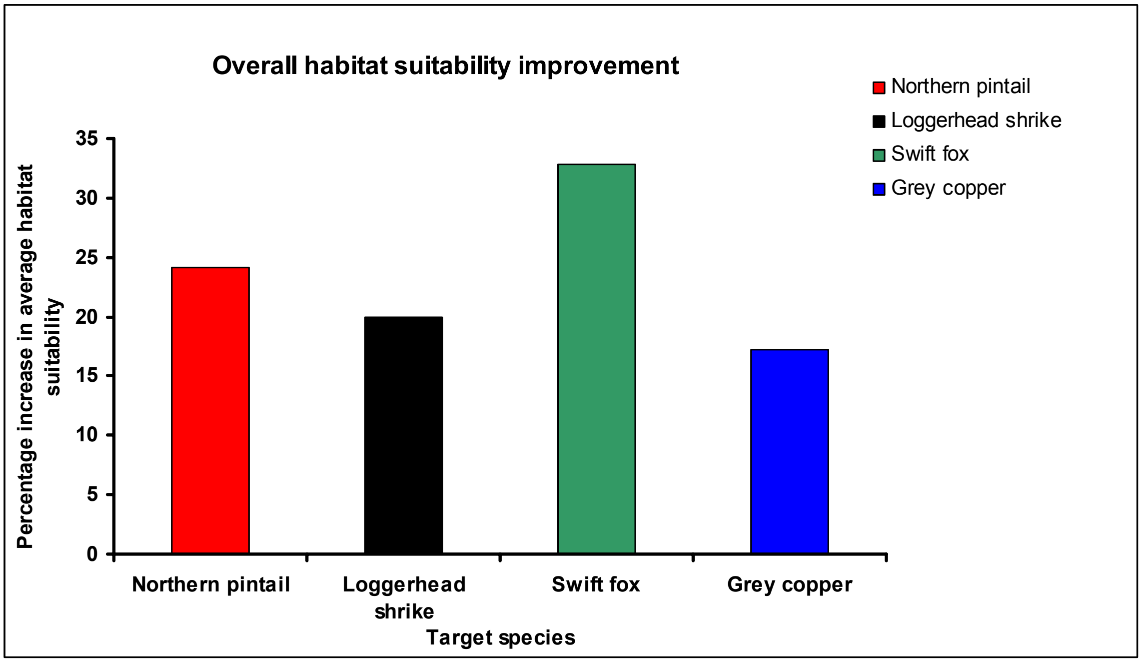


8.2.1 Target Species Habitat Suitability

Changes in average habitat suitability indices for all species are shown in Figure 8.2. Overall, accumulated average habitat suitability across all species improved by 23 percent in the optimal landscape. Habitat suitability for the Grey copper improved by 17.2 percent, for the Loggerhead shrike by 20 percent, for the Northern Pintail by 24.2 percent and for the Swift fox by 32.8

percent. Habitat suitability maps are shown in Map 8.5 – Map 8.12. A visual examination of the habitat suitability maps also reveals the scale and spatial distribution of habitat suitability across the Climax Landscape Region.

Figure 8.2 Improvement of target species habitat suitability during landscape optimization



The habitat suitability map of the Grey copper (compare Map 8.5 and Map 8.6) reveals suitable habitat distributed in small patches across the Climax Landscape Unit (the actual Climax area). Highest habitat suitability values occur in areas with hay/forage near wetlands. The optimization produced a landscape with 36059 ha hay/forage distributed in quarter sections near wetlands, a 7 fold increase of hay/forage compared to the current landscape. This habitat suitability map is a good example for the importance of small scale compositions of different landcover types (hay/forage near wetlands), which are likely not always captured by expert rules or common indispensable landscape patterns, i.e. large patches plus stepping stones plus corridors.

The habitat suitability map of the Loggerhead shrike (compare Map 8.7 and Map 8.8) reveals habitat suitability pockets at a scale of 64 ha home range size. Loggerhead shrike habitat is tied to a combination of shrub and grassland, which is naturally most prevalent in the Frenchman River Valley. The creation of shrubs and grassland in the Climax area substantially improved habitat suitability in this highly disturbed area. The optimization added 12338 ha Shrub exclusively within water and wetland buffers of 120 m, a 2.3 fold increase over the current conditions. As a result, average habitat suitability improved by 20 percent. Again, small scale features, such as shrubs distributed across a landscape may add significantly to habitat suitability for dependent species.

The habitat suitability map of the Northern pintail (compare Map 8.9 and Map 8.10) shows larger clusters of suitable habitat in areas with grassland and wetland co-occurring, primarily in the Frenchman River Valley and in the south-western part of the Climax Landscape Region. The conversion from cropland to grassland benefited habitat suitability for the Northern pintail and improved habitat suitability in some of the Climax areas.

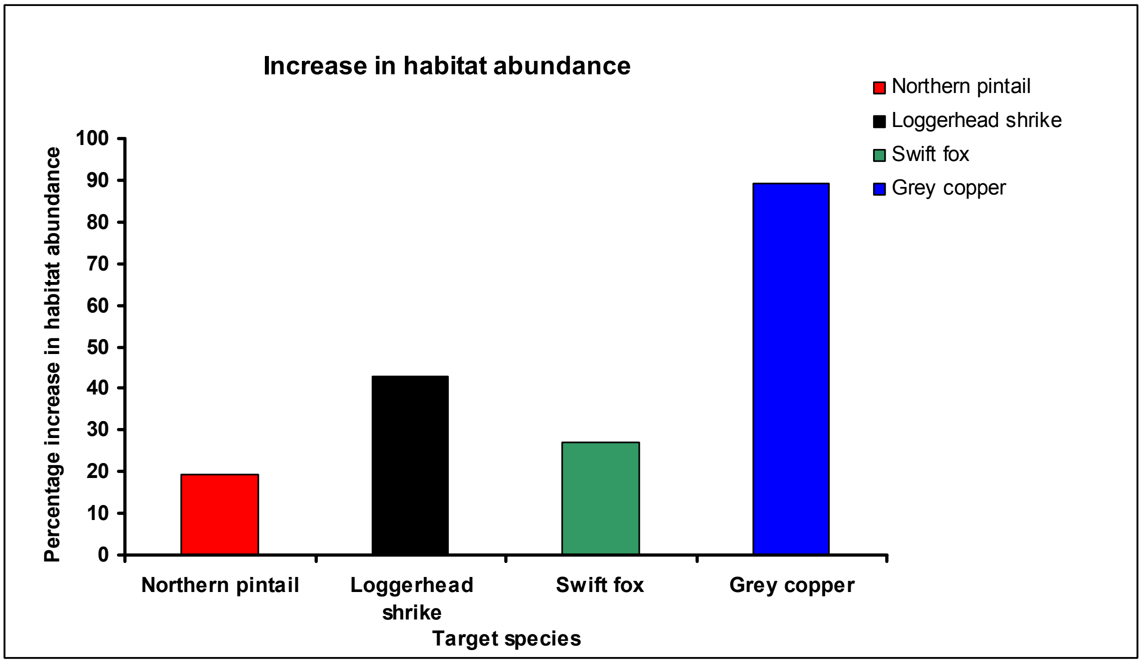
The habitat suitability map of the Swift fox (compare Map 8.11 and Map 8.12) reveals the largest contiguous habitat patches for all 4 target species. Swift fox habitat primarily consists of native grassland and is therefore coincident with the presence of large, even grassland patches. Habitat is most suitable and prevalent in the Frenchman River Valley as well as in the south-western part of the Climax Landscape Region. Conversion of cropland to grassland in the Climax area resulted in habitat suitability improvements and an overall average habitat suitability improvement of 32.8 percent.

In summary, habitat suitability was improved considerably for all 4 target species in the optimized Climax Landscape Region. Habitat suitability maps revealed the importance of particular landcover compositions at different spatial scales. It is often the combined presence of 2-3 landcover types within the home range area of a certain species, which determines suitability and abundance of actual habitat. The optimized landscape provides the best possible composition and configuration of grassland, shrubs, pasture and hay/forage under consideration of static landscape features such as water bodies, wetlands, badlands and settled areas. Based on the assumption that the selected 4 target species and their associated habitats are representative for the majority of native grassland species and that maximizing their habitat suitability implicitly maximizes related ecological processes and functions, this optimized landscape can be regarded as a biodiversity target or benchmark against which the effects of standards should be evaluated.

8.2.2 Target Species Habitat Abundance

Landscape optimization resulted in an optimized Climax Landscape Region with increased habitat abundance for all 4 target species. Actual habitat was delineated by those cells in the habitat suitability map, whose habitat suitability value was above 0.5. We used a habitat suitability threshold of 0.2 for the Grey copper, because there was no habitat above 0.5 in the current landscape. This threshold is an arbitrary choice and very difficult to justify based on empirical data. It has no direct implications for the optimized landscape and is solely used to compare changes in habitat abundance prior and after landscape optimization. Changes in habitat abundance for all species are shown in Figure 8.3.

Figure 8.3 Increase in target species habitat abundance during landscape optimization



Habitat abundance for the Grey copper increased by 89 percent from initially 99,248 ha to 187,808 ha. This is the largest increase of actual habitat area for all of the 4 selected target species. Habitat abundance for the Northern pintail increased by 19 percent from initially 145,060 ha to 172,565 ha. Habitat abundance for the Loggerhead shrike increased by 43 percent from initially 179,075 ha to about 255,743 ha. Habitat abundance for the Swift fox increased by 27 percent from initially 157,246 ha to 199,415 ha in the optimized landscape.

Overall, habitat abundance increased significantly for all 4 target species. The landscape optimization resulted in about 20 percent change or turnover in landcover types across the Climax Landscape Region. This is about half of the changeable area of 39 percent as described in 8.1.1. Comparing the 20 percent land-use change with the gains in habitat abundance reveals the efficiency of the optimization approach, but also the importance of the spatial configuration of landcover types at different spatial scales. For example, grassland and shrubs in isolation would be insufficient for the Loggerhead shrike. The combination of both within a certain area defines the species' habitat and therefore it is equally important to arrange landcover types in a particular way, so that target species can actually benefit. Landscape optimization based on habitat suitability targets reveals these particular habitat configurations and their potential location within a landscape.

8.2.3 Landscape Pattern

The optimal landscape is shown in Map 8.2. A visual inspection reveals a breakup of the large and continuous cropland area spanning across the Climax region into a heterogeneous mix of cropland, pasture as well as hay/forage quarter sections. Lots of shrub coverage was added within the 120 buffer areas surrounding wetland and water bodies. These configurational changes are based and determined by the initial data preparation, i.e. using quarter sections as transformation units and creating buffers around wetlands and water bodies. Table 8.2 shows how landcover proportions changed from the current to the optimal landscape.

Table 8.2 Changes in landcover distribution following landscape optimization

	Existing Climax Landscape Region (baseline)		**Optimized Climax Landscape Region**		
Class	**Area (ha)**	**% of Landscape Region**	**Area (ha)**	**% of Landscape Region**	**% change**
Cropland	273,107	45.31	149,306	24.75	-54.6
Grassland	246,798	40.90	305,010	50.55	+23.3
Wetland	15,295	2.53	15,295	2.53	0
Trees	391	0.06	391	0.06	0
Shrubs	9,158	1.52	21,496	3.56	+134.7
Unvegetated/Badlands	14,530	2.40	14,530	2.40	0
Water	14,870	2.50	14,870	2.46	0
Settled/Roads	6,045	1.00	6,045	1.00	0
Pasture	16,579	2.75	40,303	6.68	+136.4
Hay/Forage	4,882	0.80	36,059	5.97	+638.1
Total		100		100	

We also calculated landscape indices using Fragstats (McGarigal and Marks. 1995) to determine the most significant changes in landscape configuration quantitatively. The most prominent changes relate to landscape configuration. Meshsize (Jaeger 2000), is a widely used fragmentation index and conceptionally related to the area weighted mean patch size. Meshsize across all landcover types (landscape level index) decreased from about 44,000 ha in the current landscape to about 900 ha in the optimized landscape. This change is attributed to the breakup of the large cropland area into many smaller, quarter section sized patches of different landcover types. The LPI (Largest Patch Index) across all landcover types decreased from about 27 percent to about 22 percent in the optimal landscape and reflects the same structural change in the optimized landscape as Meshsize. Total edge and edge density reduced slightly in the optimal landscape indicating that the overall amount of edge between different landcover types remained nearly unchanged in the optimal landscape.

Overall, the optimal landscape is characterized by an increase in heterogeneity at small to medium spatial scales (6-100 ha), resulting in a mosaic of agricultural and natural landcover types instead of maximized patch sizes of single landcover types. This pattern is likely the most beneficial compromise for the 4 selected target species and a logical result of the static landscape features, which were not changed in the landscape but contributed toward habitat suitability (e.g. water and wetlands). The mosaic is also strongly determined by the choice of using quarter sections as changeable units. A different unit of change would have produced a different kind of mosaic.

Despite these particulars, the optimal landscape emphasizes the importance of heterogeneity at different spatial scales, which requires a mix of different landcover types in close vicinity. Often static features in landscapes, such as water, wetlands, badlands, saline flats or rocky outcrops may be "anchors" for land-use changes, if habitat for a certain species requires one or more of those landscape elements.

8.3 Landscape Optimization vs. Expert Rules

In Chapter 7 expert rules were applied to the current Climax Landscape Unit with the intention to test some of the candidate biodiversity standards and their potential effects on biodiversity and the performance of related ecological functions and processes. This approach is conceptionally comparable to the landscape optimization approach, because it aims for a landscape scenario with improved habitat suitability. This section compares quantitative results obtained from the application of candidate biodiversity standards by means of expert rules to those obtained from the landscape optimization. We will compare the achieved average habitat suitability indices and habitat abundance for each of the 4 target species.

Note that this comparison is based on an identical landscape extent for both the optimized Climax Landscape Region and the Climax Landscape Unit. The modified Climax Landscape Unit is embedded in the Climax Landscape Region (Map 8.3) and habitat suitability indices were derived for the area covering the Climax Landscape Region. The corresponding habitat suitability maps for the Climax Landscape Region with expert rule changes are shown in Maps 8.13 – 8.16.

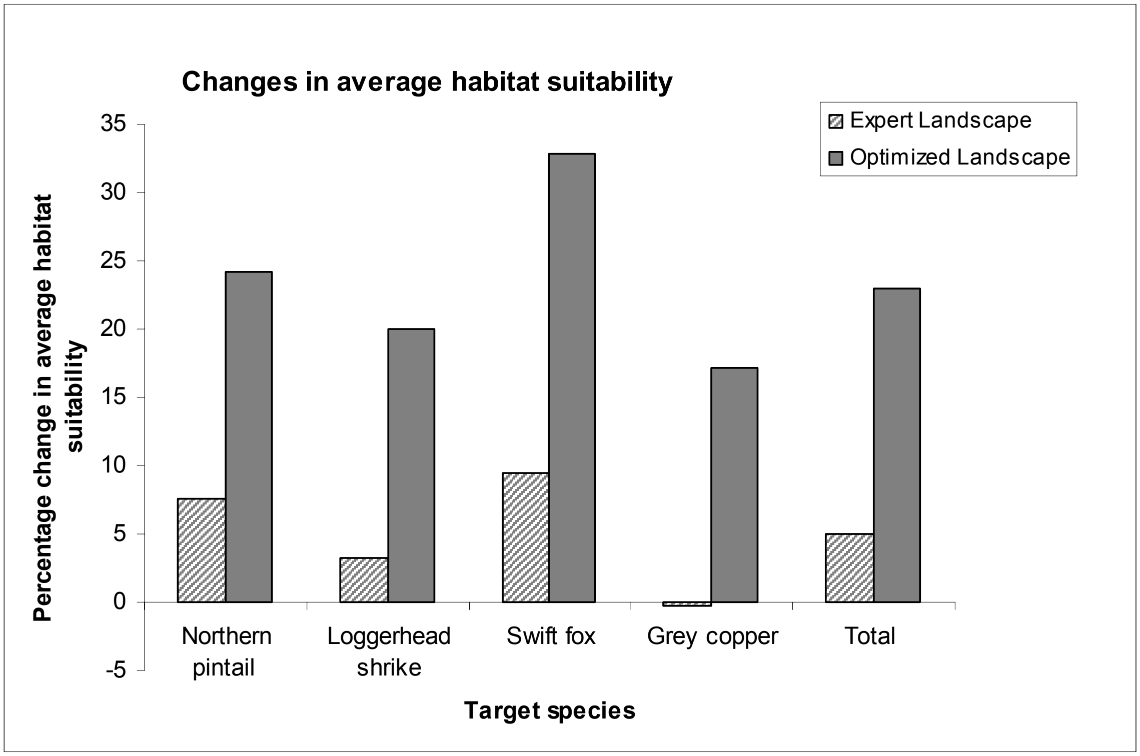
8.3.1 Comparison of Target Species Habitat Suitability

Average habitat suitability indices for each of the 4 target species were calculated for the expert landscape and compared to those obtained from the landscape optimization. Overall, accumulated average habitat suitability across all 4 target species improved by 5 percent in the expert landscapes compared to a 23 percent improvement in the optimal landscapes. Figure 8.4 shows a comparison of the average habitat suitability values for each species.

Habitat suitability for the Grey copper actually declined by 0.3 percent in the expert landscape compared to a 17.2 percent improvement in the optimized landscapes. This discrepancy is caused by a lack of small scale changes in the expert rules. The Grey copper habitat requires the co-occurrence of wetland and hay/forage within a relatively small area of 6 ha. The only prescribed change to improve habitat suitability for this species would be to add hay/forage fields adjacent to existing wetlands. This conversion was likely not considered in the expert rules.

Habitat suitability for the Loggerhead shrike improved by 3.2 percent in the expert landscape compared to a 20 percent increase in the optimal landscape. This discrepancy is caused by the lack of shrub creation in the expert rules. The expert landscape did not increase shrub cover. The transition rules for the landscape optimization, however, provided for shrub encroachment within 120 m buffer zones around wetlands and water bodies. This addition of shrub landcover in the vicinity of grassland resulted in a significant improvement of habitat suitability for the Loggerhead shrike.

Figure 8.4 Comparison of habitat suitability improvement in expert vs. optimized landscape



Habitat suitability for the Northern pintail improved by 7.6 percent in the expert landscape compared to a 24.2 percent improvement in the optimal landscapes. This is actually the closest match between both approaches, means that the habitat requirements of the Northern pintail are likely best captured by the candidate biodiversity standards as applied to the expert landscape. It is very likely the conversion of cropland to grassland near wetlands, which boosted habitat suitability for the Northern pintail, because this species directly benefits from a grassland/ wetland combination within a 650 ha home range.

Habitat suitability for the Swift fox improved by 9.4 percent in the expert landscape compared to a 32.8 percent increase in the optimal landscape. This discrepancy may be attributed to differences in the spatial allocation of new grassland. Although expert rules aimed for large patches of natural landcover, landscape optimization tried to accumulate grassland adjacent to existing grassland in order to maximize the amount of grassland within a 1080 ha home range. Landscape optimization may have been simply more efficient in allocating grassland to areas with larger impacts on habitat suitability of the Swift fox.

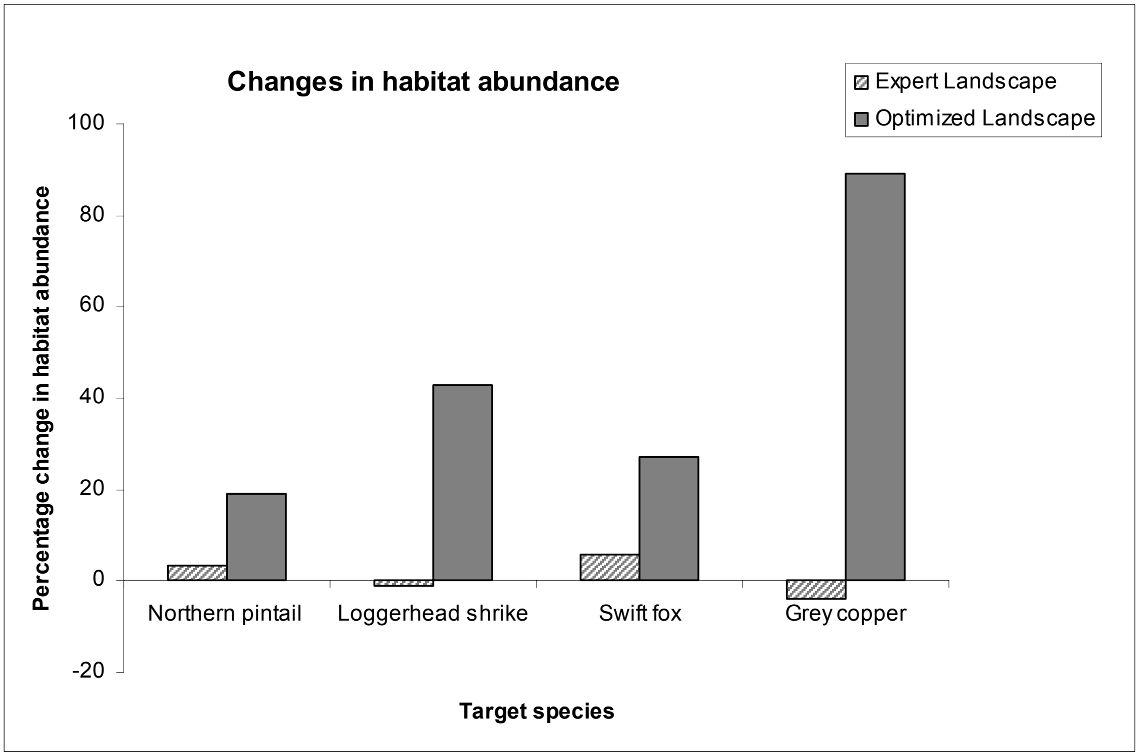
Overall, landscape optimization revealed a landscape configuration with a much higher yield in habitat suitability compared to the landscape created by applying candidate biodiversity standards by means of expert rules. This discrepancy is partly attributed to the differences in the transition rules, but also reveals interesting insights into the importance of small scale features and the complementary aspects of species' habitat.

Habitat is seldom defined by just one “natural” landcover type, but requires a particular mix and adjacency of natural and/or agricultural landcover types. These particulars are seldom captured sufficiently in expert rules or commonly known conservation or biodiversity standards. Or, it means that those standards must be applied to habitat suitability maps instead of landcover types at a variety of spatial scales. The “big winner” of the landscape optimization was the Grey copper, whose habitat requires adjacency of hay/forage and Wetland at a very small spatial scale. This habitat was “created” and maximized throughout the optimization, but not considered in the expert rules.

8.3.2 Comparison of Target Species Habitat Abundance

Both, expert rules and landscape optimization resulted in increased habitat abundance for all 4 target species. Actual habitat was identified by using the same threshold values as introduced in 8.2.2. Figure 8.5 shows a comparison of the habitat abundance values for each species.

Figure 8.5 Comparison of changes in habitat abundance for expert vs. optimized landscape



Habitat abundance for the Grey copper decreased by 4 percent in the expert landscapes compared to a 89 percent increase in the optimal landscape. Habitat abundance for the Loggerhead shrike did not increase in the expert landscape, but increased by 43 percent in optimal landscape. This slight discrepancy between habitat suitability improvement and lack of added new habitat for the Loggerhead shrike indicates that expert rules resulted in creation of low quality habitat (with HSI values below 0.5). Habitat abundance for the Northern pintail increased by 3.2 percent compared to 19 percent in the optimal landscape. Finally, habitat abundance for the Swift fox increased by 5.6 percent compared to a 27 percent increase in habitat in the optimal landscapes.

Habitat abundance changes are correlated to changes in average habitat suitability. Habitat abundance, however, represents higher quality habitat and is therefore a more useful measure at a landscape scale. Landscape optimization resulted in substantially higher gains in high quality habitat compared to those obtained from the expert landscapes and are very likely caused by the same mechanism as discussed in 8.3.1.

8.4 Conclusions

Landscape optimization of the Climax Landscape Region revealed a landscape scenario with maximized habitat suitability for a set of 4 selected target species. This optimal landscape scenario represents a potential biodiversity target or reference condition for a working landscape and should not be confused with a conservation design. The major difference between reserve selection algorithms and our proposed landscape optimization is the inclusion of land-use changes and the acknowledged co-existence of human land-use and species habitat. The optimal landscape could have produced much better habitat suitability improvements for our selected target species in the absence of socio-economic constraints. The result is therefore the best possible compromise between partially conflicting targets. These conflicts arise from the incompatibility of many human land-use practices with species habitat requirements, but also from dissimilar habitat requirements of different species.

The following main conclusions can be drawn from this exemplary landscape optimization exercise:

- landscape heterogeneity at different spatial scales is important
- habitat for a species is usually composed of more than just one natural landcover type
- species operate at different spatial scales, which must be considered in biodiversity standards
- landscape optimization has the potential to reveal optimal landscape composition and configuration for best possible habitat suitability and abundance of multiple selected surrogate target species
- landscape optimization does not reveal whether habitat abundance and configuration is “enough” or “optimal” for population or metapopulation viability
- effects of corridors, stepping stones and connectivity in general on population viability can only be explored by optimizing a landscape for population viability rather than habitat suitability
- an optimal landscape scenario represents a potential biodiversity target, benchmark or reference condition, based on which effects of changes in agricultural management or land-use conversions can be evaluated
- habitat suitability patterns in optimal landscapes can add to existing candidate biodiversity standards and enhance expert rules
- landscape optimization produced a landscape scenario with results superior to those obtained from expert rules in enhancing existing and creating new habitat for a set of target species

If potential or feasible changes in agricultural land-use practices (transition rules) are defined along with a set of socio-economic constraints, landscape optimization may be a powerful tool to reveal the maximum benefit of those changes to a set of representative surrogate species, which in turn may indicate the performance of related ecological functions and processes. As such, landscape optimization may be used to enhance existing biodiversity standards and to effectively support identification of habitat based biodiversity targets in agricultural landscapes – the main objective of the biodiversity theme under NAESI.

8.5 Map Set

Map 8.1 Climax Landscape Region – current conditions plus added buffer zones around wetland and water (baseline)

Map 8.2 Climax Landscape Region – optimized landscape

Map 8.3 Climax Landscape Region – expert landscape

Map 8.4 Inverse Irrigation Potential (CLI) – areas with CLI equal 3 were excluded from the landscape optimization

Map 8.5 Grey copper habitat suitability in current landscape (baseline)

Map 8.6 Grey copper habitat suitability in optimized landscape

Map 8.7 Loggerhead shrike habitat suitability in current landscape (baseline)

Map 8.8 Loggerhead shrike habitat suitability in optimized landscape

Map 8.9 Northern pintail habitat suitability in current landscape (baseline)

Map 8.10 Northern pintail habitat suitability in optimized landscape

Map 8.11 Swift fox habitat suitability in current landscape (baseline)

Map 8.12 Swift fox habitat suitability in optimized landscape

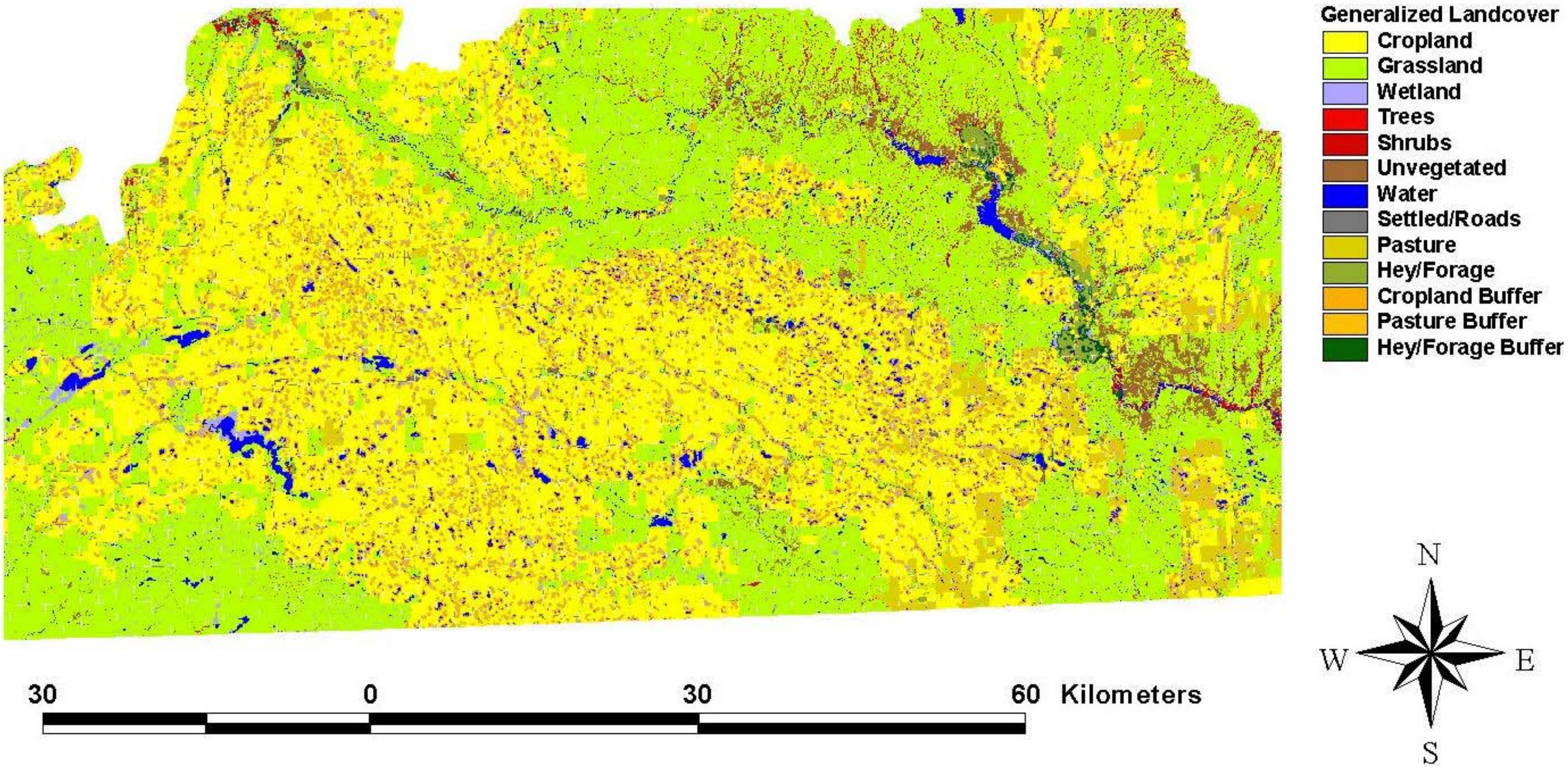
Map 8.13 Grey copper habitat suitability in expert landscape

Map 8.14 Loggerhead shrike habitat suitability in expert landscape

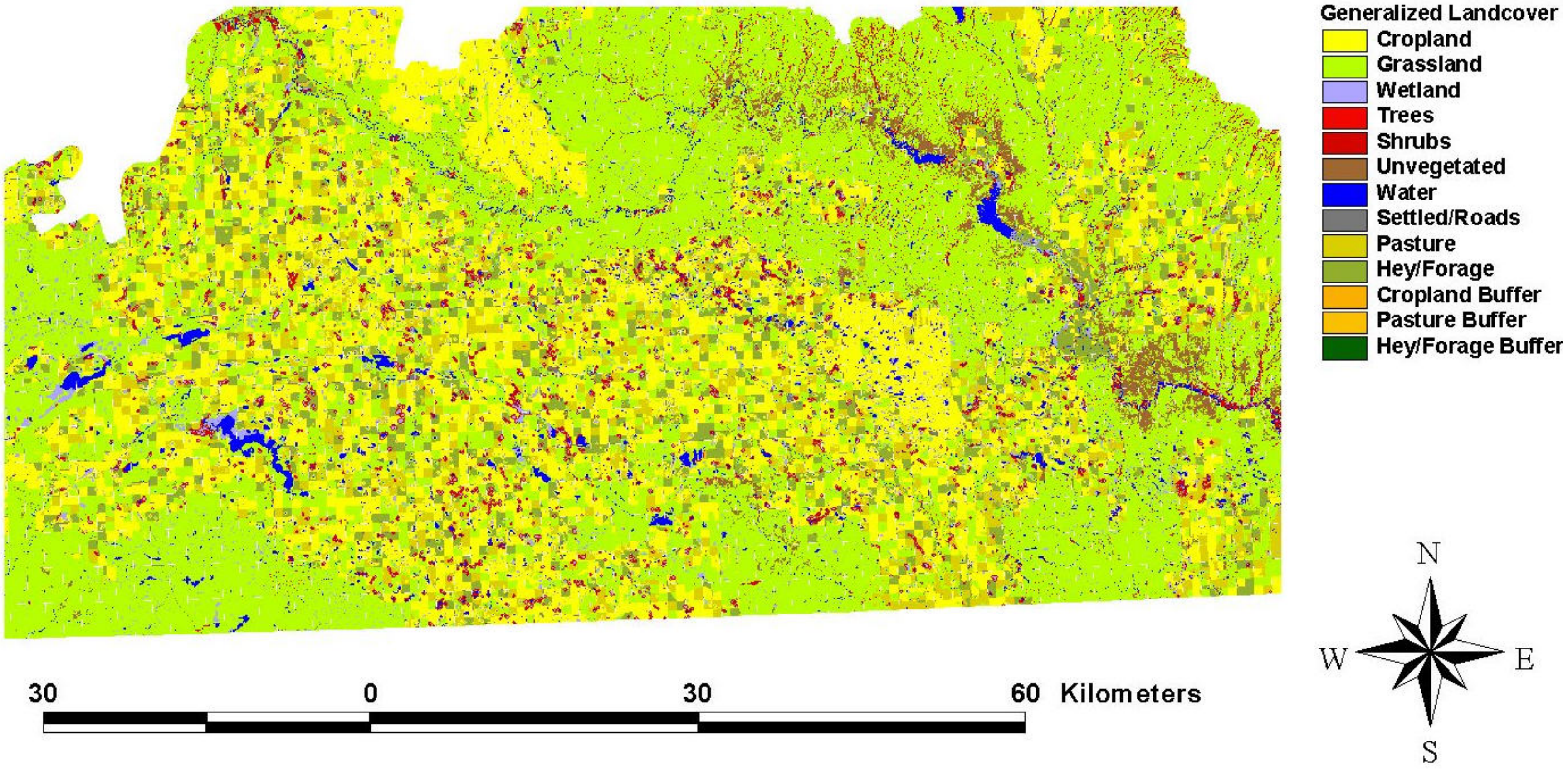
Map 8.15 Northern pintail habitat suitability in expert landscape

Map 8.16 Swift fox habitat suitability in expert landscape

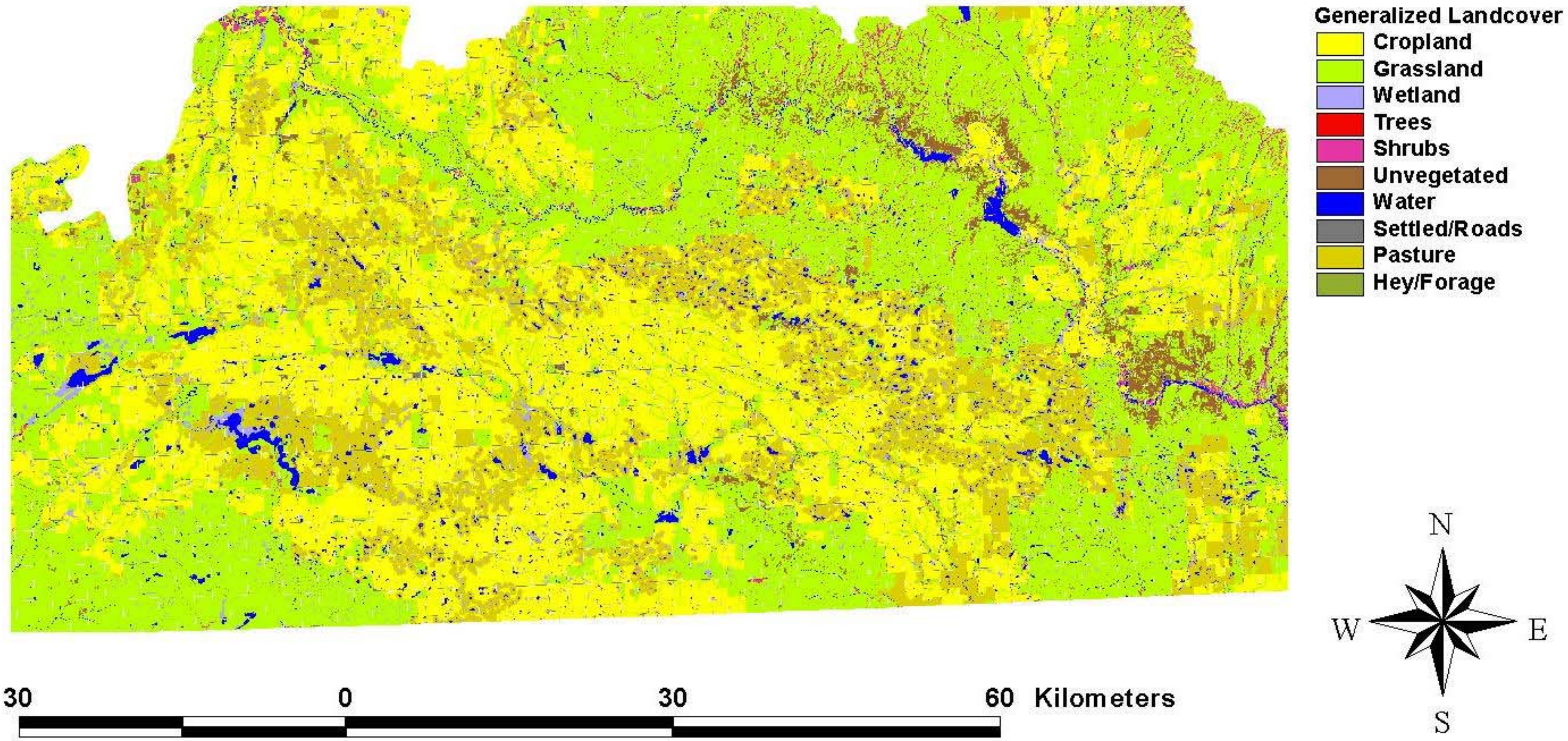
Map 8.1 Climax Landscape Region – current conditions plus added buffer zones around wetland and water (baseline)



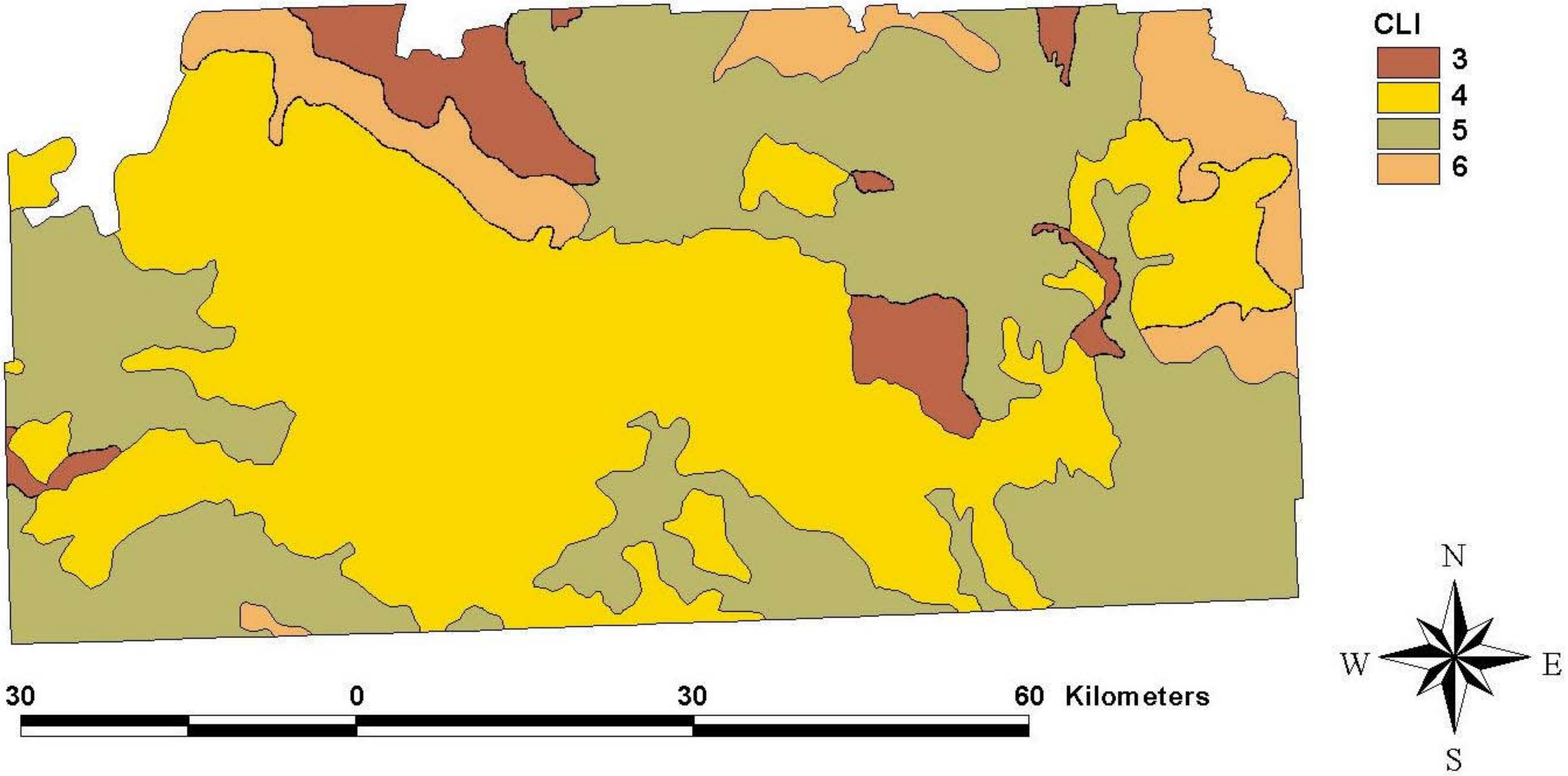
Map 8.2 Climax Landscape Region – optimized landscape



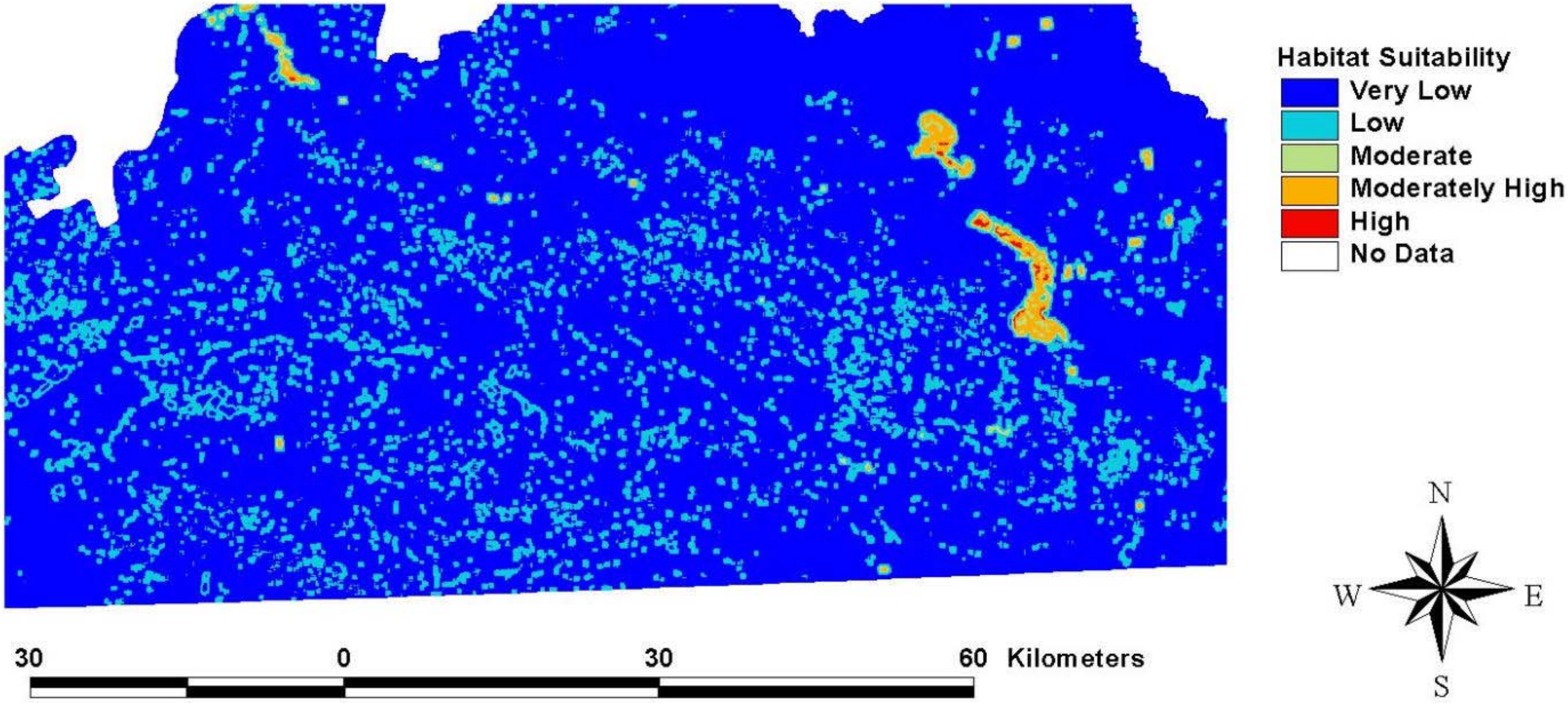
Map 8.3 Climax Landscape Region – expert landscape



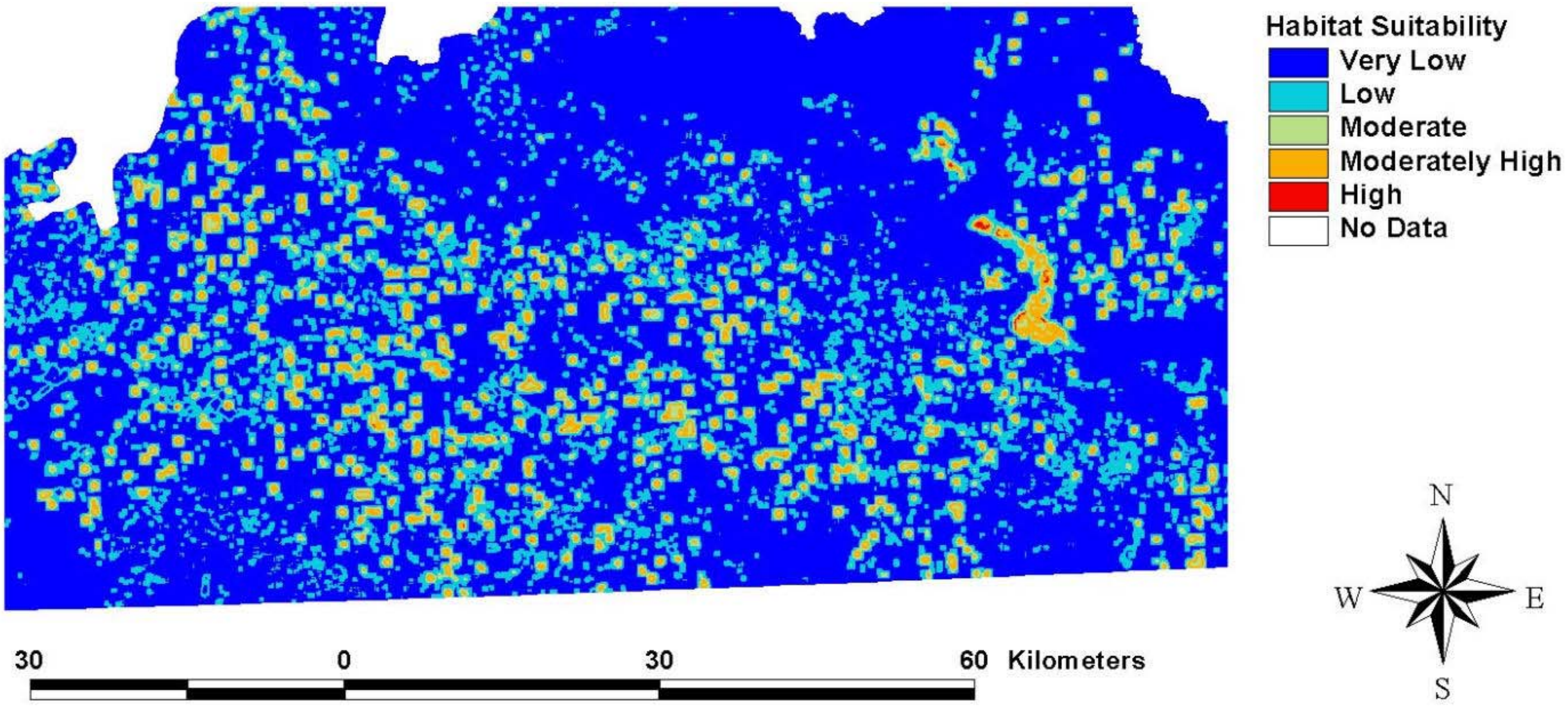
Map 8.4 Inverse Irrigation Potential (CLI) – areas with CLI equal 3 were excluded from the landscape optimization



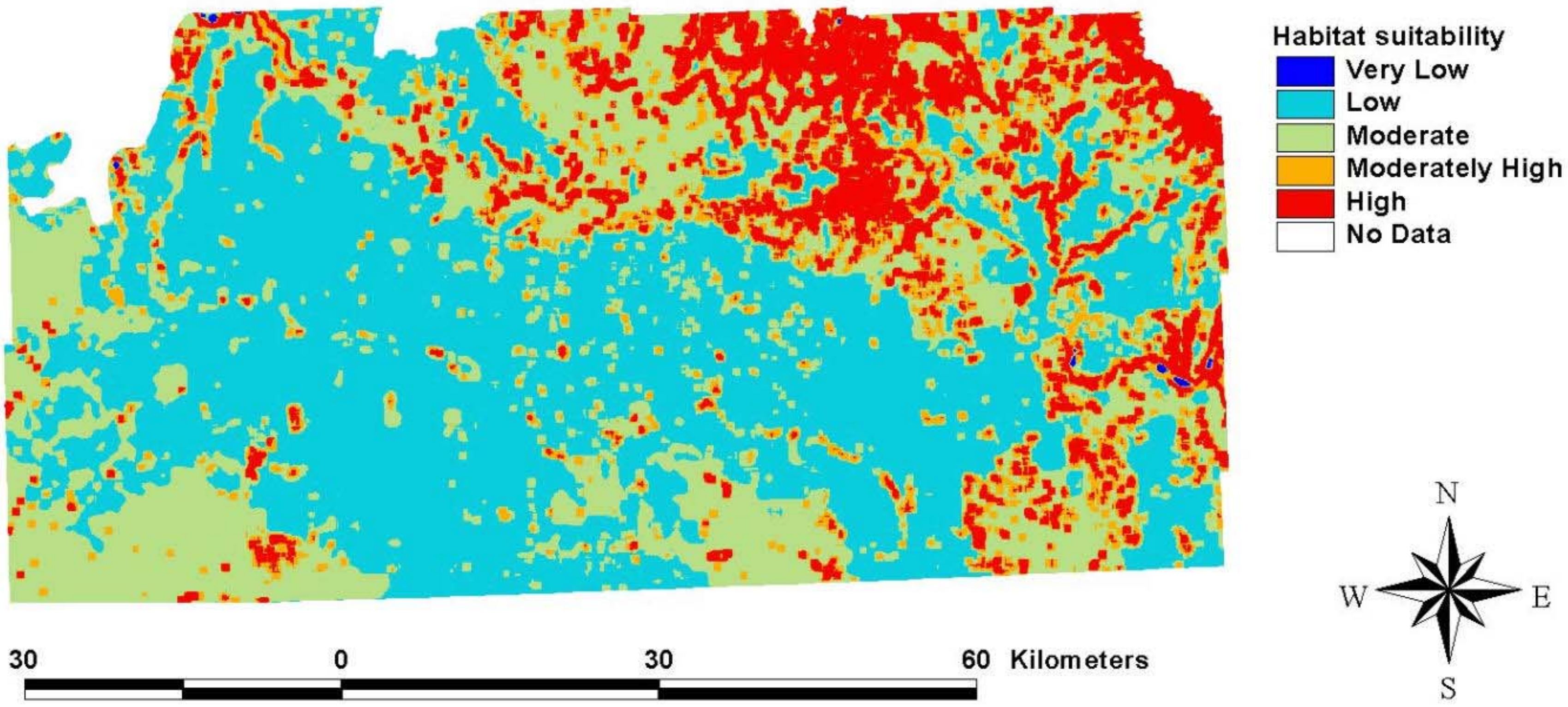
Map 8.5 Grey copper habitat suitability in current landscape (baseline)



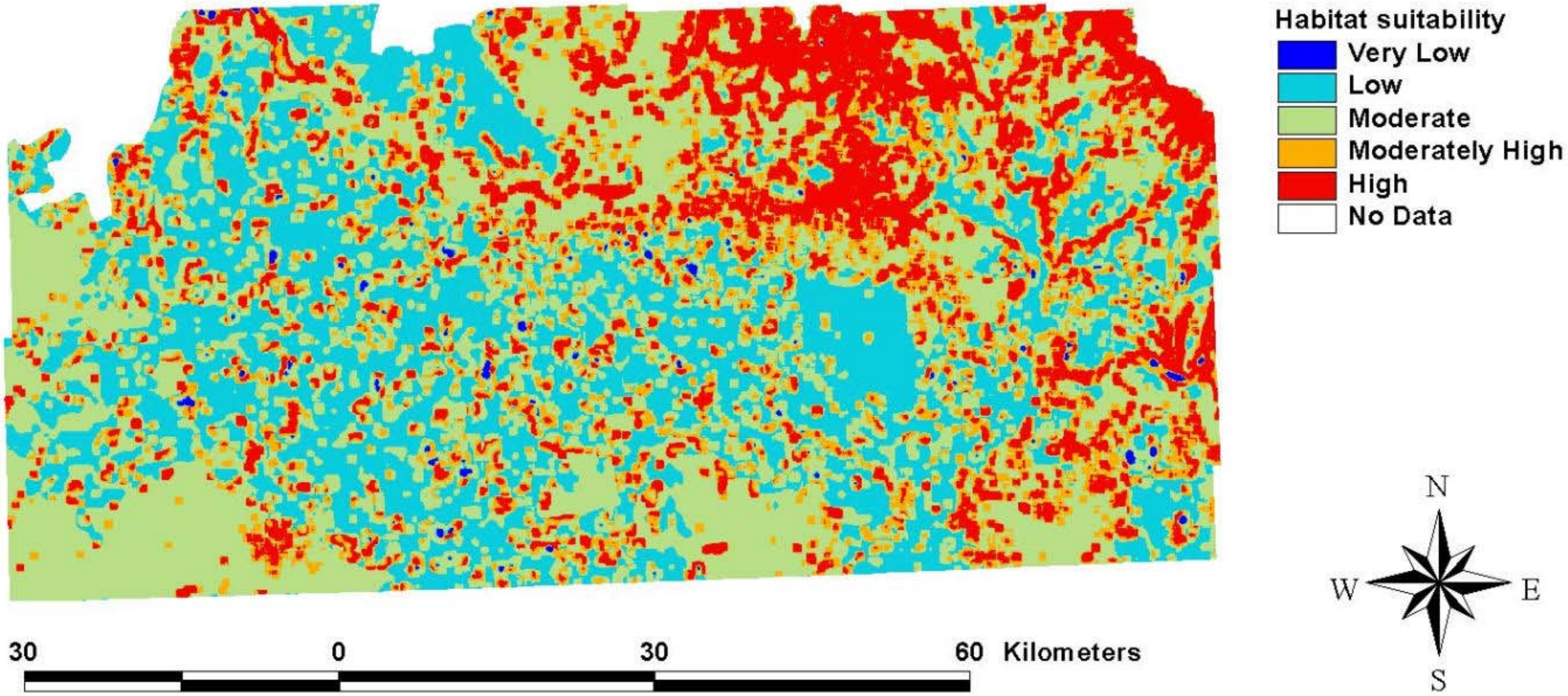
Map 8.6 Grey copper habitat suitability in optimized landscape



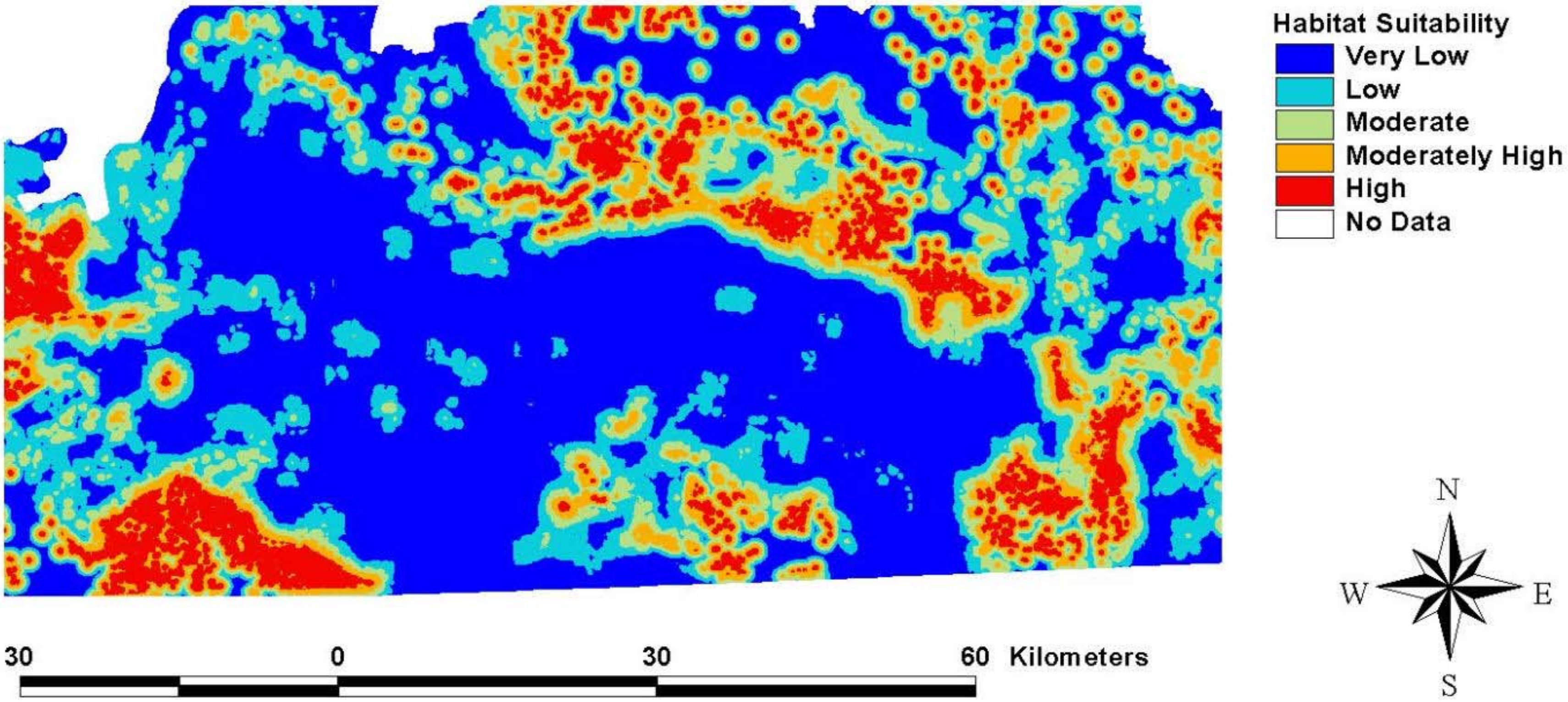
Map 8.7 Loggerhead shrike habitat suitability in current landscape (baseline)



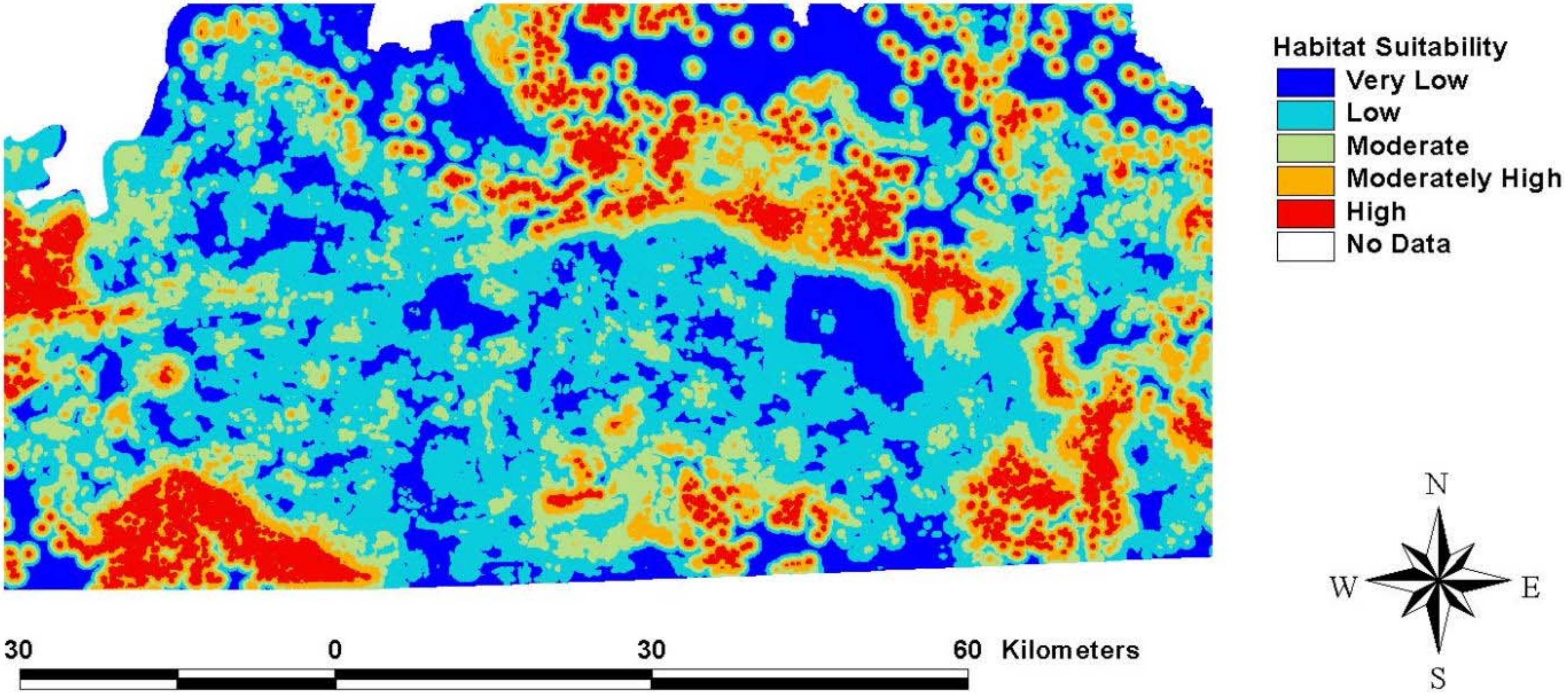
Map 8.8 Loggerhead shrike habitat suitability in optimized landscape



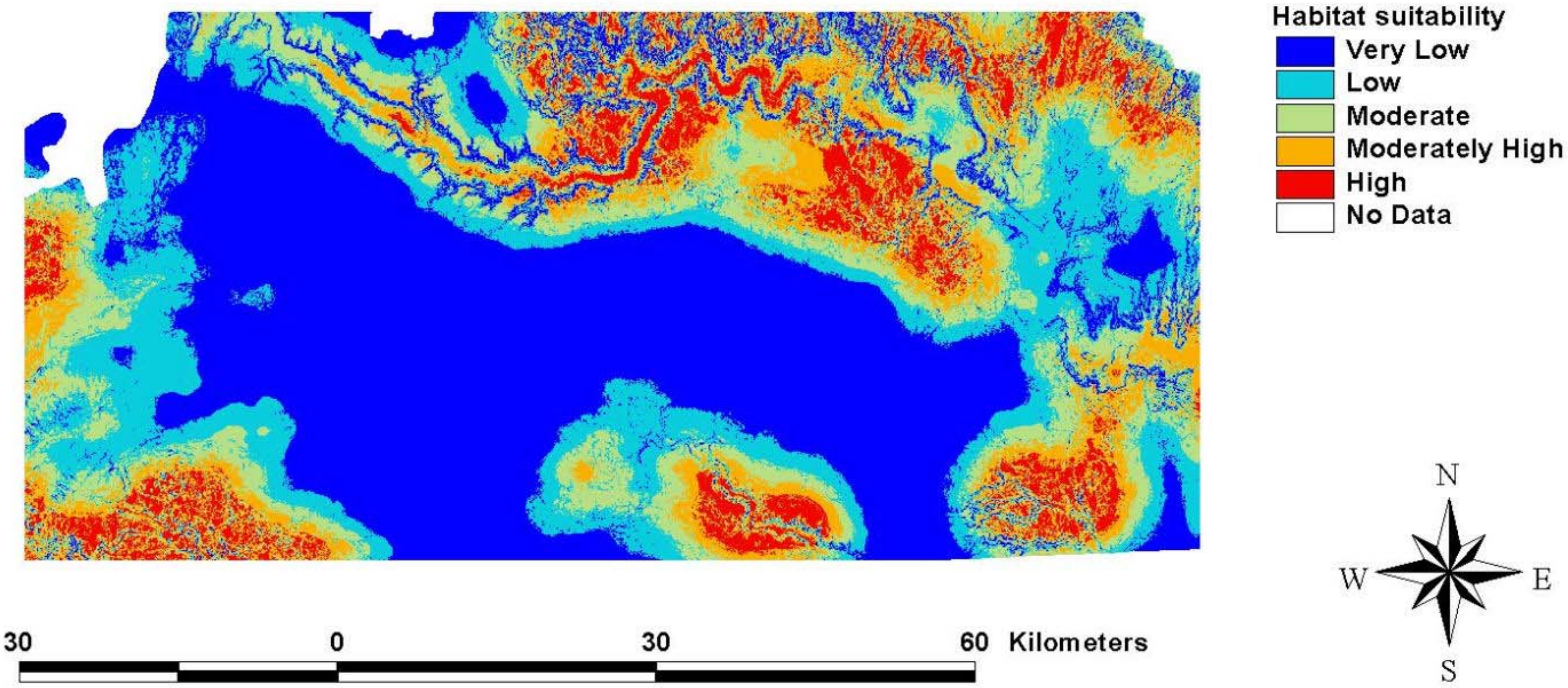
Map 8.9 Northern pintail habitat suitability in current landscape (baseline)



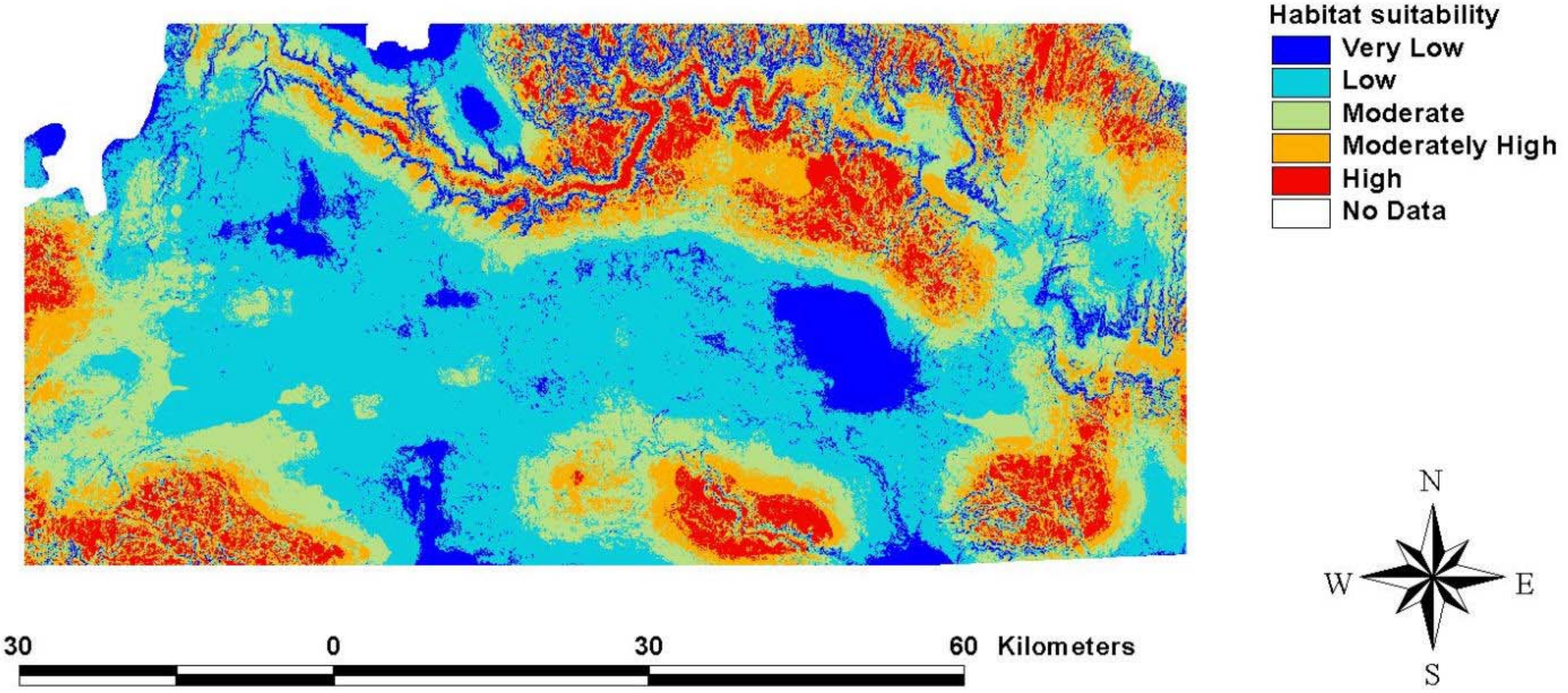
Map 8.10 Northern pintail habitat suitability in optimized landscape



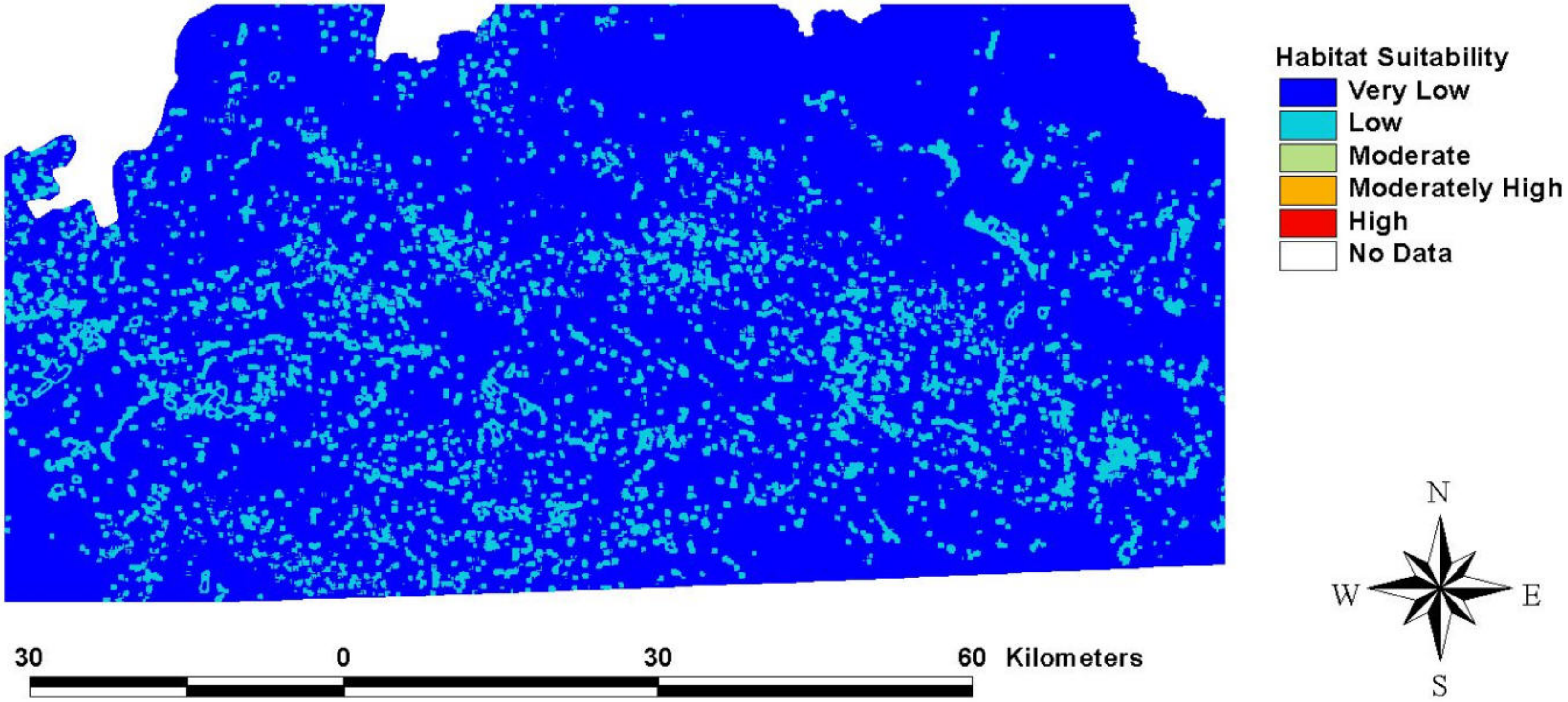
Map 8.11 Swift fox habitat suitability in current landscape (baseline)



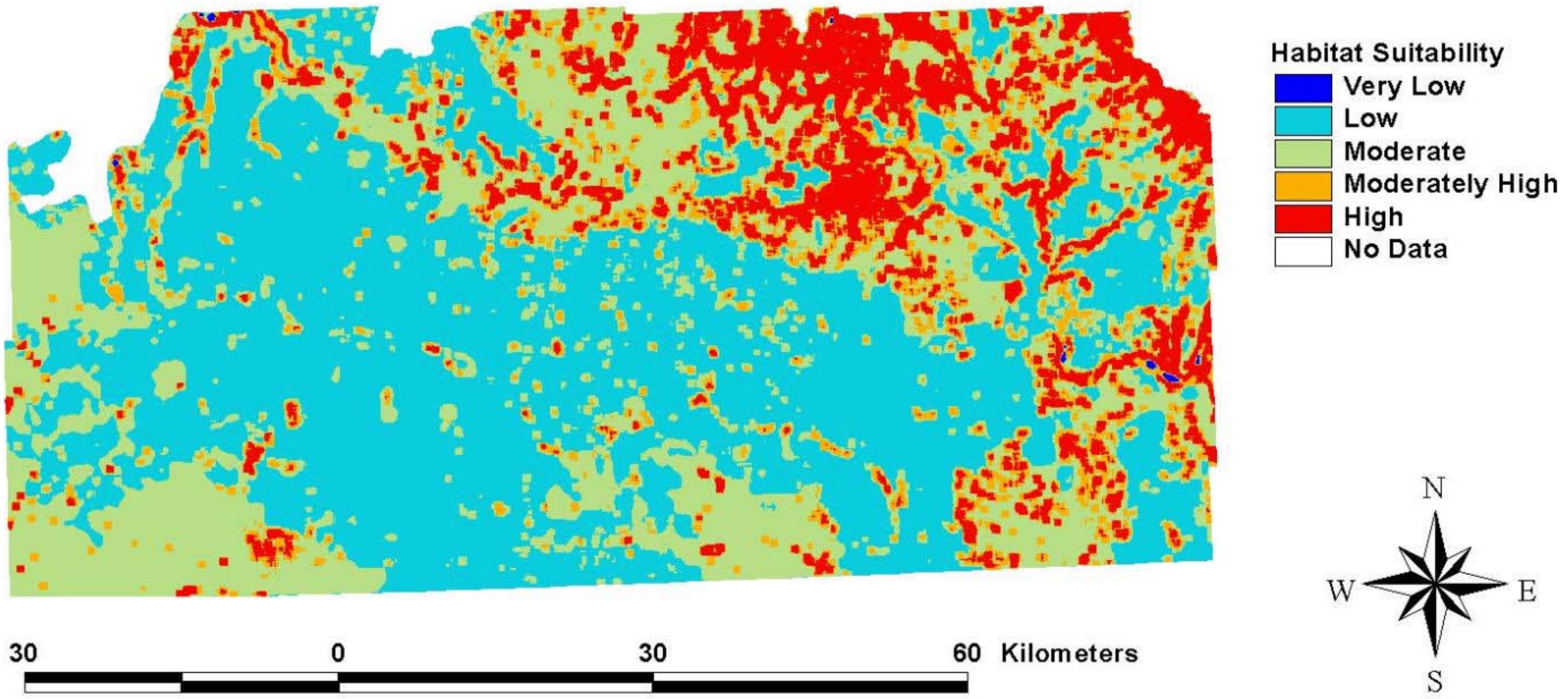
Map 8.12 Swift fox habitat suitability in optimized landscape



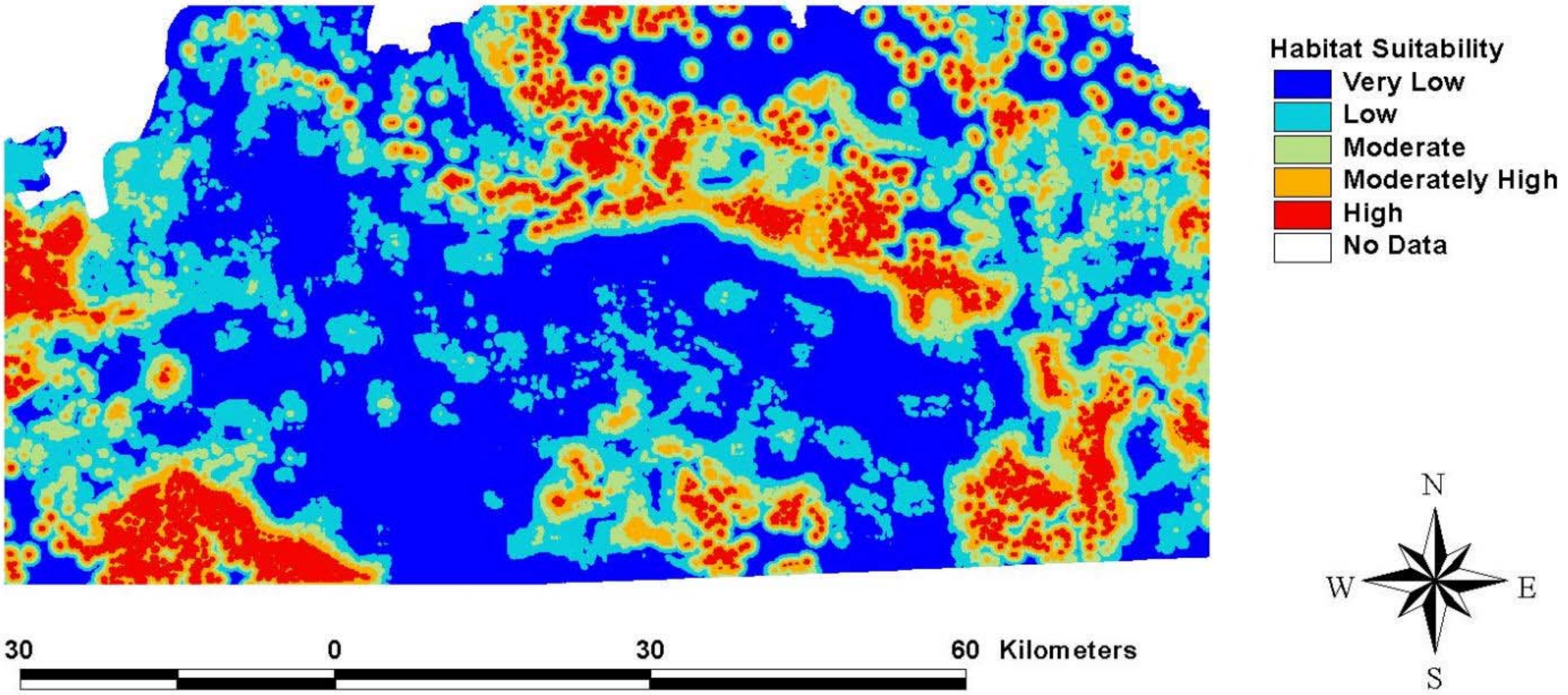
Map 8.13 Grey copper habitat suitability in expert landscape



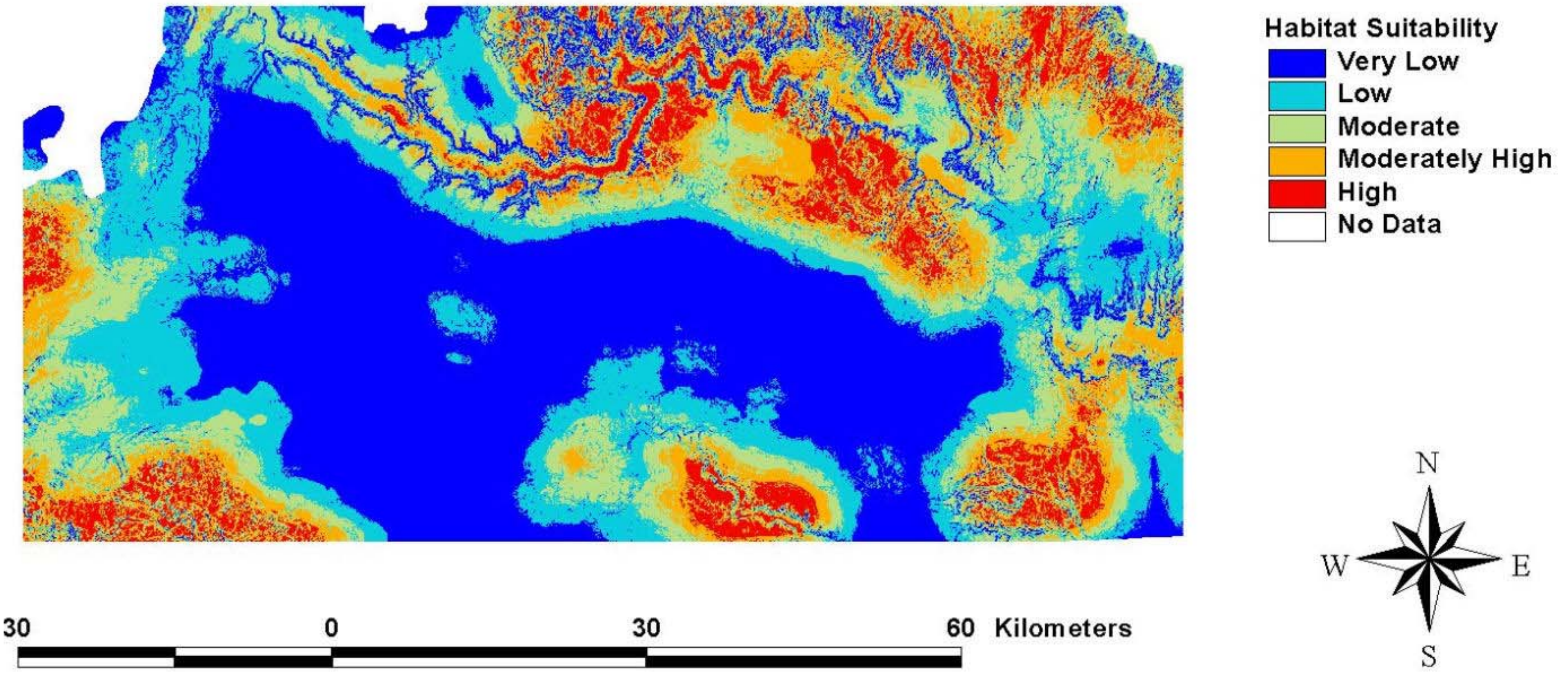
Map 8.14 Loggerhead shrike habitat suitability in expert landscape



Map 8.15 Northern pintail habitat suitability in expert landscape



Map 8.16 Swift fox habitat suitability in expert landscape



8.6 References

Jaeger, J.A.G. 2000. Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. Landscape Ecology 15 (2): 115 – 130.