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## **Development of car-based accessibility in Switzerland from 1950 through 2000: First results**

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## Development of car-based accessibility in Switzerland from 1950 through 2000: First results

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### Abstract

Transport systems are and have been built primarily to extend the physical radius or reach of people and companies. Accessibility can be understood as the number of opportunities available for social and economic life that can be reached within a travel time appropriate to the relevant purpose.

In the present paper, an accessibility model for private vehicle traffic is developed using resident population as the indicator of the number of opportunities. As a first draft, the earlier road networks are generated by tracing back the growth of the motorway network, while maintaining the 2000 network otherwise. The non-motorway links are assigned with attributes appropriate for the different years. Next, travel time matrices for the approximate 3,000 municipalities are calculated for the different years of the study, which are 1950, 1960, 1970, 1980, 1990 and 2000. Finally, accessibilities are calculated as the travel time weighted sums of opportunities. In order to determine the potential of a location or municipality, the resident population at the destination is included in the calculations.

The results of the analyses will give indications as to which areas benefited from the improvements of the road network and how the distribution of accessibility for all municipalities has changed over time.

### Keywords

Accessibility – Network modelling – Swiss regional structure – 1950 to 2000 – 2<sup>nd</sup> Swiss Transport Research Conference – STRC 2002 – Monte Verità

## 1. Introduction

Transport systems have been built primarily to expand the reach of both people and industry. One measure of the resulting change in the spatial system is the change in *accessibility*. For this, two components must be considered. First, what can be reached, and second, how much effort is necessary to get there? Accessibility is both the primary product of transport infrastructure and the link between transport infrastructure and land use.

During the last fifty years, private vehicle traffic has changed dramatically; the private car is no longer a luxury in Western Europe. The interregional infrastructure for private vehicles has been changing from an ill-fitting, multipurpose, slow road network into a fast, single-purpose, strong, hierarchical motorway and road network. In recent years, many studies of European changes in accessibility (Schürmann *et al.*, 1997; Bruinsma and Rietveld, 1993) have sought to determine the impact of major infrastructure developments, primarily railroads and motorways, on the accessibility distribution in Europe and their future effects.

The approach of the present work is to look backwards in order to trace changes in accessibility for private vehicle traffic over the period from 1950 through 2000, in 10 years steps. The population size at the municipal level is used as a first approximation of the number of activity opportunities.

This research is conducted as part of the project, “Development of the Transit Transport System and its Impact on Spatial Development in Switzerland”, within the framework of Action 340 of the European Co-operation in Scientific and Technical Research (COST) consortium, entitled “Towards a European Intermodal Transport Network: Lessons from History”.

In the following, the measurement of accessibility as implemented here is explained, followed by a description of the data sources used in the analysis. The main part of the paper is the discussion of changes in accessibility in Switzerland. The results are then summarised and interpreted in the discussion.

## 2. Model

The starting point for the present model is the road network of Switzerland in the year 2000. It consists of approximately 20,000 links, 15,000 nodes and 3,000 districts. From this, different road networks are built for the years of interest (that is, 1990, 1980, 1970, 1960 and 1950).

This is accomplished by removing the motorways from the model and adjusting the mean speed for the different road types in each year. These parameter values for the links are obtained from old editions of the HCM (1985) as well as Dietrich *et al.* (1998), and are shown in Table 1.

Table 1 Mean speed of the link types for different years [km/h]

Type of link	Year					
	1950	1960	1970	1980	1990	2000
Motorway-120	85	95	110	112	114	114
Motorway-100	85	95	90	92	94	94
Motorway-80	85	95	75	77	79	79
Motorway-access	30	30	30	30	30	30
Main road	40	45	55	65	70	70
Connection road	25	40	50	60	60	60
Collection road	30	35	45	50	50	50
Access road	25	25	35	40	40	40
Alpine transit road	35	40	50	60	60	60
Alpine main Road	30	35	45	50	50	50
Alpine collection road	25	25	35	40	40	40
Alpine access road	15	20	25	30	30	30
Urban main road	22	22	22	22	22	22
Urban collection road	17	17	17	17	17	17

Source: own calculation with data from HCM (1985) and Dietrich *et al.* (1998)

An “all-or-nothing” traffic assignment is used to calculate the travel time from each municipality to every other municipality in Switzerland. This yields a 2903 x 2903 matrix, applying nearly 9 millions trips on the Swiss road network (i.e., one trip between each zone).

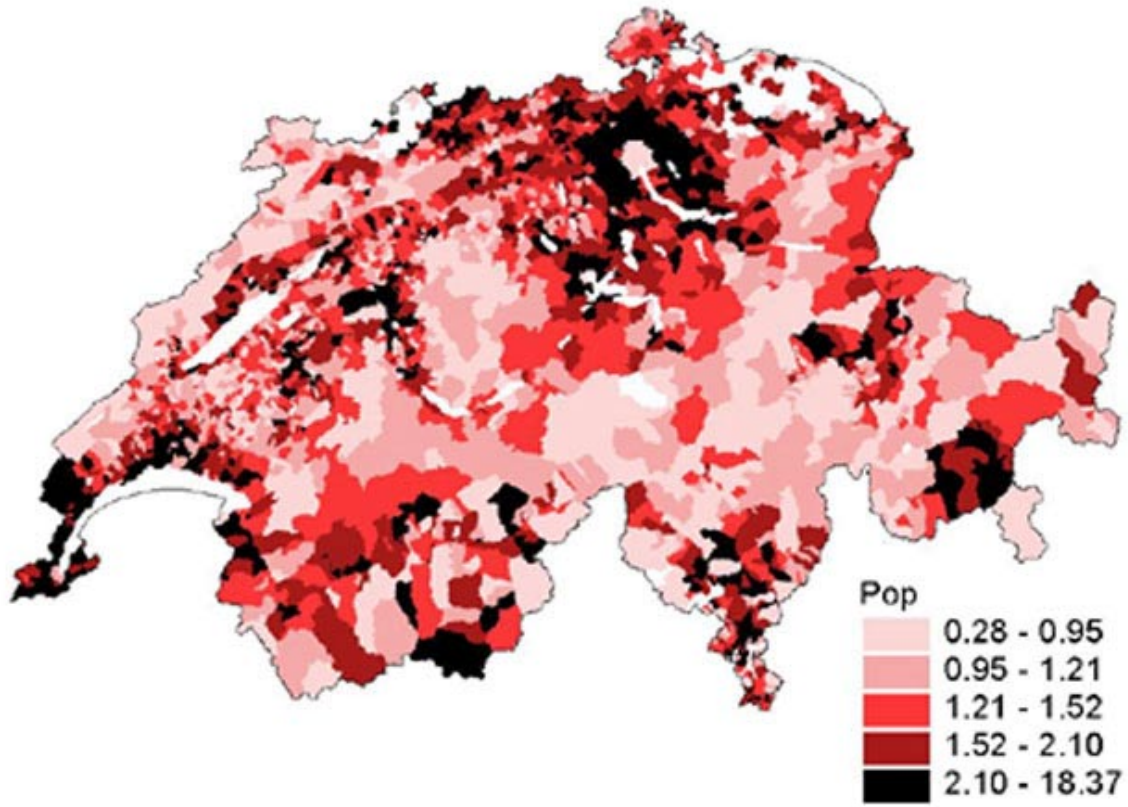
For some links, this method suggests unrealistically high traffic volumes. Thus, it is necessary to set the capacity restraint function as a constant; in other words, there is no increase in travel time for a link, irrespective of the load. The calculation of the travel times is performed with help of the transport model VISUM (PTV, 2000). The connection between the centroid of a municipality and the road network is established by choosing the closest node of the minor road network (all roads excluding motorways). No access or egress times are considered; this means that travel time reflects the path between the nearest minor node by the origin and the destination.

The population data come from the censuses of 1950, 1960, 1970, 1980 and 1990. In the case of 2000, population data of the Bundesamt für Statistik from the beginning of 1999 is employed, (see Figure 1). The extended time frame leads to some minor problems regarding the analyses and the mapping of the results. In some cantons, for example Thurgau or Basel-Landschaft, municipalities have been divided or merged; these changes are not considered within this data set. Additionally, the ArchView files containing the municipality borders uses 1998 as the reference year and thus leaves some small gaps in the map. However, the aforementioned problems affect only smaller municipalities; thus, the calculation of accessibility is still precise enough given the extended time frame and the broad scope of the study.

Looking at either of the maps, population or accessibility change, one should keep in mind that municipalities with a large physical area may appear more important than smaller areas, such as suburban areas. Figure 1 shows the change in population from 1950 to 1999 on a municipal level. It shows an overall relative growth, due to an increase in the Swiss population in absolute terms from 4.715 to 7.123 million (BFS, 1999).

In the report of the Bundesamt für Statistik (1992), the changes in population for different periods are discussed. The period between 1941 and 1970 showed a significant increase in population, which came about in conjunction with a strong economy. The peripheral areas, the rural parts, and especially the non-tourist, alpine valleys lost population. On the other hand, the cities, and particularly their surroundings, gained population. From 1970 to 1990, cities lost population to their surrounding municipalities. This led to an increasing agglomeration effect around the larger centres. Additionally, the Rhone Valley and the urban areas of Tessin saw population increases. In rural areas, only regions with economically inferior situations lost further people, (i.e., the Gotthard area, Jura, Canton Uri).

Figure 1 Population change at the municipality level from 1950 to 1999, by quintile (1.0 means the same number of residents in 1999 as 1950)



### 3. Accessibility Measurements

In the fields of transportation engineering and urban planning, as well as in the relevant literature, various definitions are used for accessibility. They are also dependent on the goal of the study. In the present work, accessibility is defined as (Geurs and Ritsema van Eck, 2001):

...the extent to which the land-use transport system enables [groups of] individuals or goods to reach activities or destinations by means of a [combination of] transport mode[s].

Though several different approaches have been developed since the fifties to measure accessibility, only the two major concepts in use are discussed below. Both of these approaches reveal the different levels of infrastructure in a region and areas relevant to the region, as well as what activity opportunities are present for the regional inhabitants.

#### 3.1 Isochrone approach

The isochrone approach to accessibility measurement focuses on the number of activity points that can be reached in a given time. This yields the number of activity points (i.e., people, places of work, shopping opportunities) accessible in a given amount of time. This is a transparent method but also disregards activity points that are just outside the set travel time and the differential impact of the travel times between the reference point and the opportunity.

#### 3.2 Potential accessibility

Another way to measure accessibility is to weight attractiveness of the activity points with the necessary travel time to these points by means of a negative potential function (See Kwan, 1998, for a discussion of other possible weighting functions). The main challenge here is to find the appropriate exponent,  $\beta$ , that determines the destination choice of the people, which can vary over time. In the past, the  $\beta$  factor should have been larger than today, but these values would have to be derived from old traffic surveys, which are not available yet. In the literature, the range for the  $\beta$  factor reaches from 0.5 at a regional level (Simma *et al.*, 2001) to 0.01 for Europe (Schürmann *et al.*, 1997). In the present study, the  $\beta$  factor is taken as 0.1 and kept constant across periods.

$$AccPop_i = \sum_{j=1}^{j=2903} A_j * \exp(-\beta * c_{ij})$$

AccPop <sub>i</sub>	accessibility to people living in municipality, <i>i</i>
A <sub>j</sub>	the number of residents of municipality, <i>j</i>
c <sub>ij</sub>	travel time by private vehicle between the municipality <i>i</i> and municipality, <i>j</i>
β	exponent

The number of activity points in the origin itself, here defined by population, must also be considered. For this, four different classes of municipalities were considered and average internal travel times determined. The first is for cities (> 100,000 inhabitants) with an average travel time of 15 minutes, the second for towns (30,000 – 100,000 inhabitants) with a travel time of 10 minutes, the third for villages (5,000 – 30,000 inhabitants) with a travel time of 7 minutes, and the last for small villages (< 5,000 inhabitants) with a travel time of 4 minutes.

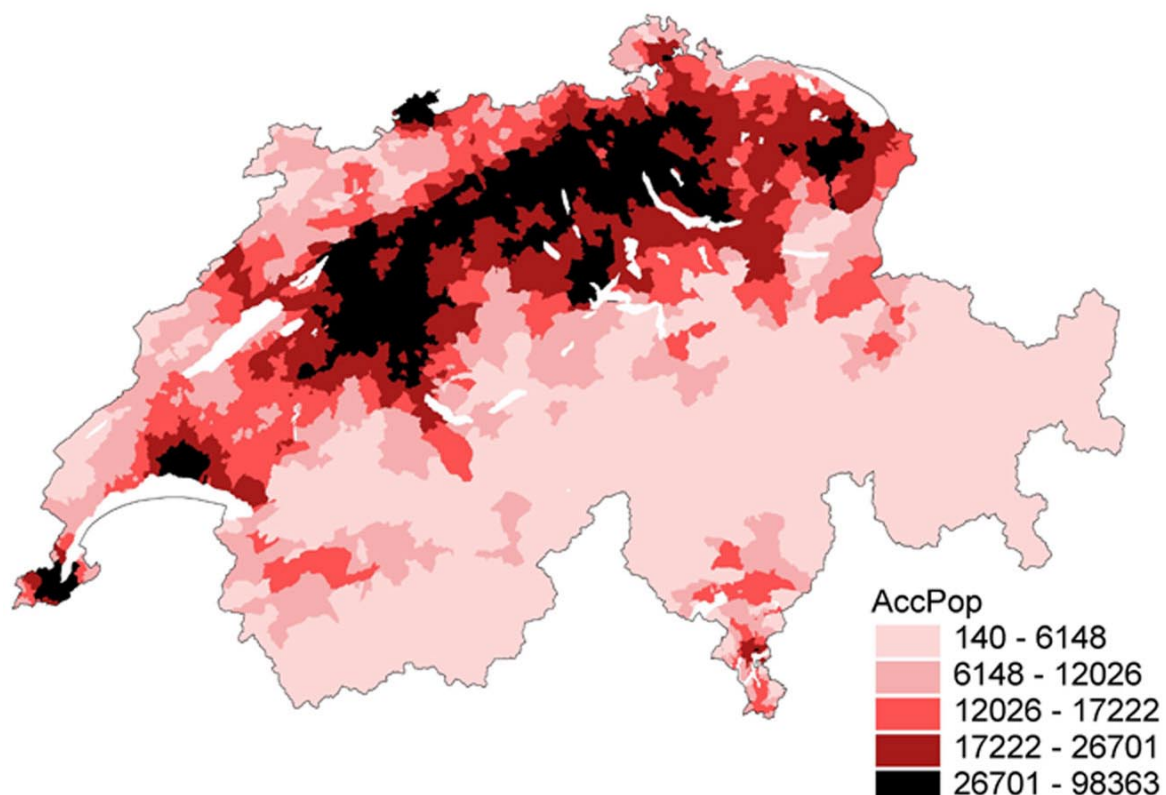


## 4. Results

In 1950, the major urban areas (see Figure 2), Zurich, Bern, Basle, Geneva, Lausanne, St. Gallen and Lucerne, had a clear absolute accessibility advantage over the other parts of Switzerland. The only band of high accessibility is in the Mittelland, spreading between Bern and Zurich. With the exception of the Rhone valley, large parts of the mountain regions have low accessibility values. The bottlenecks of the Swiss major road network between regions are also visible, for example in the area around the Urner and Walen Lakes.

A second calculation of accessibilities is done with the road network of 1950 but with the population data of 2000. This shows little change overall. However, the loss of population in some areas (e.g., Glarus) and the gain around others (Zuger and Vierwaldstätter Lakes) are apparent.

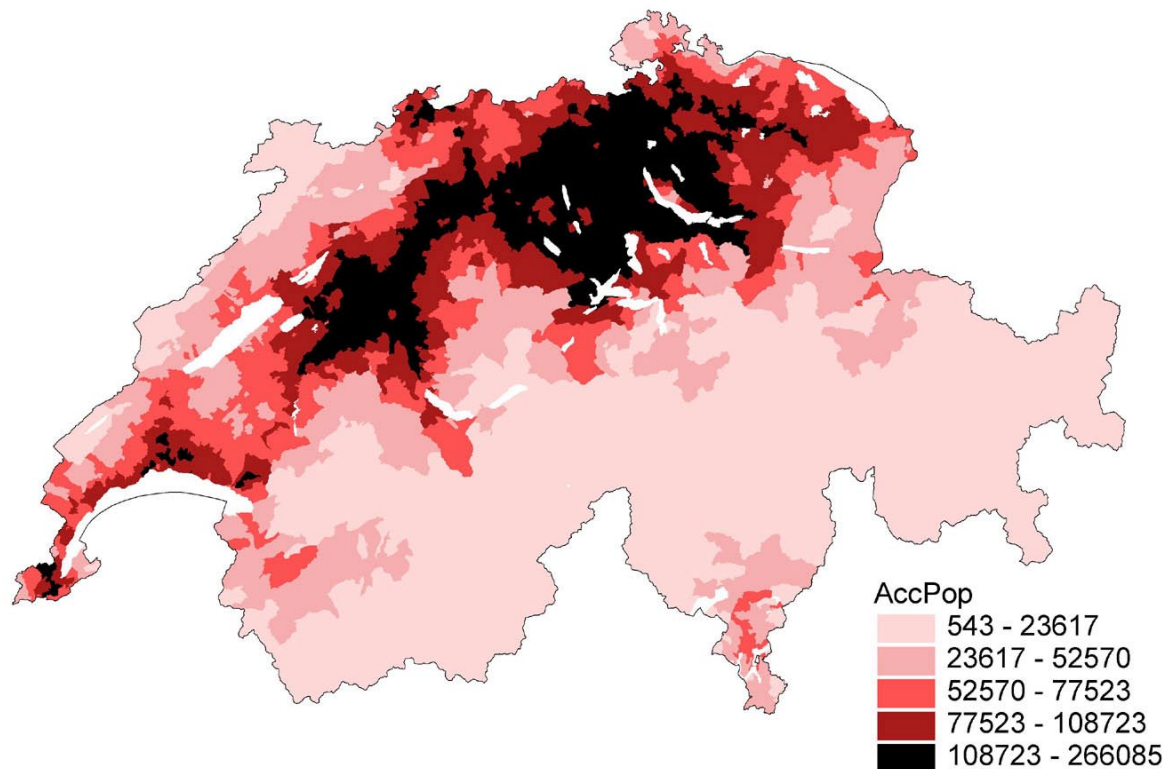
Figure 2 Absolute accessibility for the year 1950, by quintile (1950 network and population)



In 2000 (see Figure 3) the locations in the highest quintile of accessibility are concentrated in a circular area around Zurich including the Bülach, Olten and the northern part of the

Vierwaldstätter Lake. Around Bern, a cross-shaped area with municipalities of high accessibility can be seen, leading from Biel to Thun and from Solothurn to Fribourg. Around Lake Geneva, the distribution has changed from two main peaks, Geneva and Lausanne, to a more homogeneous appearance, with two additional peaks at Vevey and Nyon.

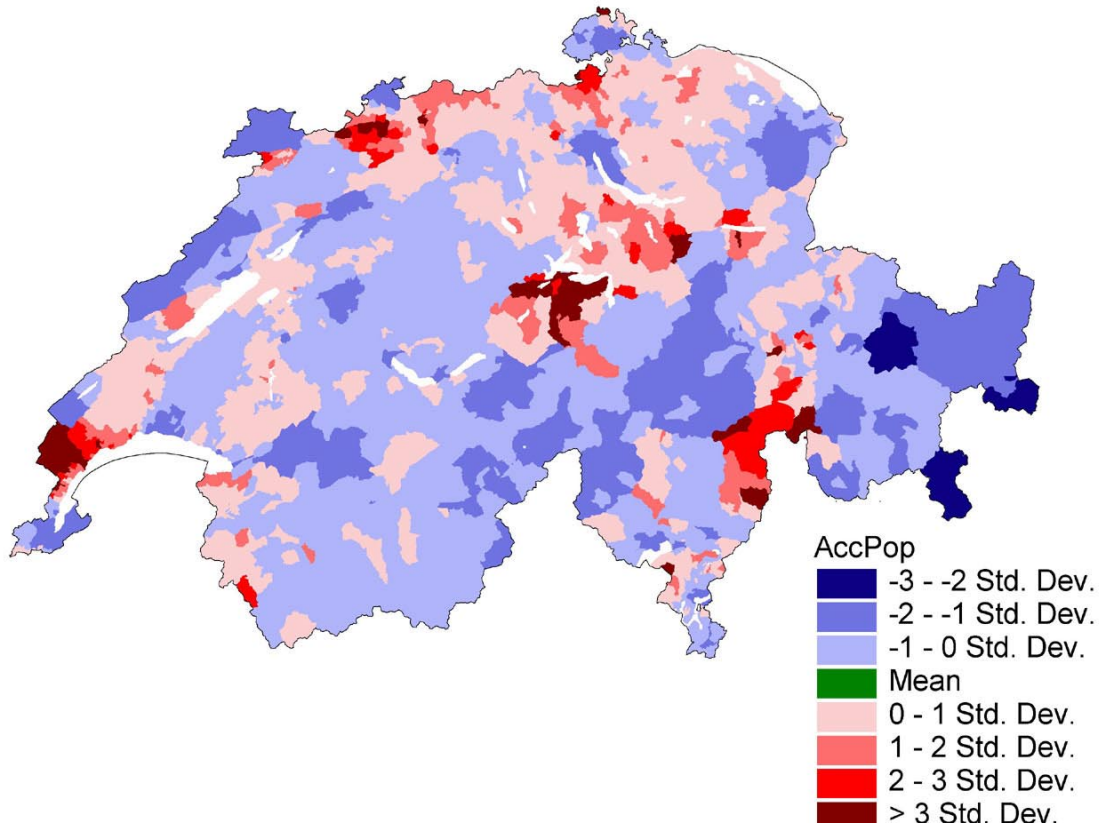
Figure 3 Absolute accessibility for the year 2000 by quintile (2000 network and population)



If the accessibility changes between 2000 and 1950 are considered (see Figure 4), the removal of some bottlenecks, like Walen Lake (N 3), Gotthard (N 2) and San Bernadino (N 13) brought major changes to areas now reached by motorways. Additionally, some border areas have improved considerably, such as Glattfelden – Eglisan (N 51, N 50), Möhlin – Rheinfelden (N 3), South of Basel, West of Yverdon-Les-Bains (N 5, N 9), and the Nyon area (N 1).

The changes within urban areas are small, as there was already a high level of accessibility in the fifties. The alpine areas without motorway access, such as the Engadin, Appenzell, and the Vorderrhein areas, have stayed on a low level. However, none of the municipalities have in 2000 a lower accessibility than 1950.

Figure 4 Relative change from 1950 to 2000 in accessibility in standard deviation



## 5. Discussion and further work

In the present work, the change of accessibility for population over time, from 1950 to 2000, is calculated. The relationship between spatial development and the effects of infrastructure is a very complex one. Thus, it is not simple to find the causal connections (Metron, 2000). Many theories have been developed (Hansen, 1959; Wilson, 1967; Kesselring et al., 1982) and empirical studies have found various interesting results. However, many questions remain open.

One problem is that most studies examine only a short period, and thus the conclusions reached or hypotheses discussed can only be generalised to examined time frame. It would be interesting to use these theories with data sets from other periods as well. However, data over longer time frames is not always available.

The problems with such short time periods are obvious from the distribution of accessibilities shown here for the different years, (see Figure 5). In the fifties as well as in the sixties, cities had a significant accessibility advantage over the countryside. In the seventies, all areas profit, and the distribution curve for accessibility became steeper.

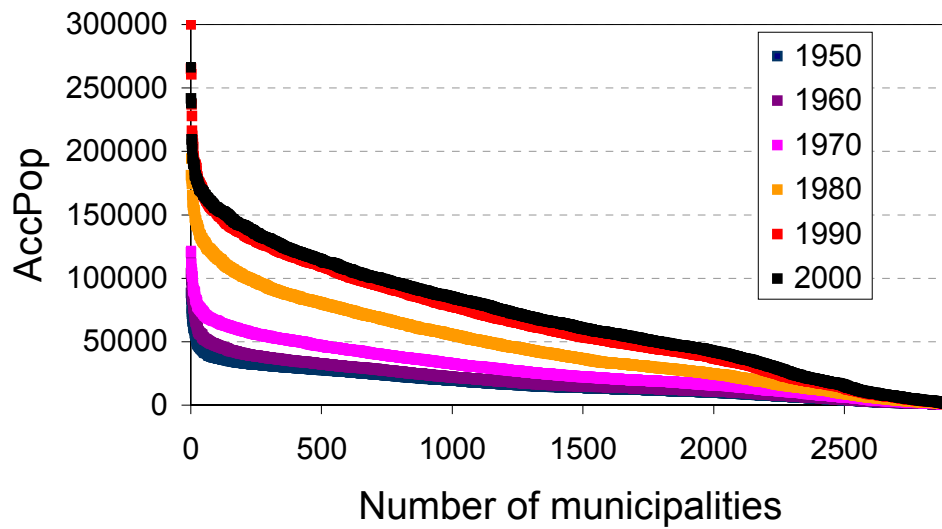
The most important changes occurring between 1970 and 1980 are in the distribution between municipalities and the decrease in the difference between cities and the rural areas. In addition, in the next period (1980 to 1990), this trend continued, with some municipalities overtaking the major urban areas, with respect to their accessibilities.

The present paper is only a first step in a challenging research project. The following steps are planned or already in progress:

The development of the road network should also include the Hauptstrassen network. In the present model, only opportunities within Switzerland are considered, but some areas with high populations (Geneva, Basel, etc.) are close to the border. This means that the model must be enlarged to the border areas in neighbouring countries in order to be more realistic.

The accessibility calculations should also be repeated considering other relevant data, such as places of work and shopping opportunities.

Figure 5 Distribution of municipal accessibilities (1950-2000)



As a final but interesting step, the weighting function needs further considerations. On one hand, the  $\beta$  factor for the potential function should be calibrated for different periods and perhaps for different regions as well, and on the other hand the use of the potential function as such has to be checked.

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