Ecological Modelling of Effects of Development Scenarios for the Vistula River Valley (Poland)

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Abstract

The Vistula River has still retained a semi-natural character for most of its length and is considered to be one of most valuable rivers in Western and Central Europe. The research area represents an extensively managed landscape, with high nature values and biodiversity, being important part of the ECONET Poland. Presently the Vistula river basin is exposed to various environmental stresses including hydro-technical measures aimed at flood control and water transport, water pollution and loss in biodiversity due to development and intensification in use of agricultural lands.

The "Vistula Econet Development and Implementation (VEDI)" project is a joint Dutch-Polish pilot approach for assessing the ecological impact of various (hypothetical) land use scenarios in the Vistula River Valley (from Warsaw to Włocławek) in Poland, by using the LARCH computer model filled with local ecological data. Five scenarios for future land use were developed in consultation with various stakeholders during a two-day workshop in May 2004.

LARCH analysis indicates that fragmentation presently does not threaten the favorable conservation status of the species assessed. Most of the species have either nearly sustainable, sustainable or highly sustainable networks. The modelling results show that scenario 1 "Maximum river regulation and infrastructure development", has a pronounced negative effect in comparison to the present situation, in particular on the species dependent on steep banks and sandbanks habitats. On the other hand Scenario 3 "Renaturalisation" affects most of the selected species positively, including the species of semi-aquatic and forest habitats.

The review of the effects on the two Natura 2000 areas showed that especially Scenario 1 will have a profound effect in the Natura 2000 area Dolina Środkowej Wisły- Middle Vistula Valley area. The effects on the Kampinos National Park are much less. The spatial analysis with LARCH has yielded useful results. It was recommended that ecological modeling (e.g. with LARCH) should be applied in the decision making process regarding all spatial developments that concern Natura 2000 areas.

More detailed information regarding the outcomes of the analysis can be found on the website: http://vediproject.org or http://www.vediproject.org

Key words: biodiversity, LARCH, Vistula, modelling, metapopulation.

Introduction

Biological diversity is highly dependent on the quality, quantity and spatial cohesion of habitats. Fragmentation of natural areas severely affects the abundance of species. The effects of the development of the natural environment can be assessed through modeling of the ecological impacts on the indicator species aiming to support interactive policymaking. The "Vistula Econet Development and Implementation (VEDI)" project is a pilot approach for assessing the ecological impact of various (hypothetical) land use scenarios in the Vistula River Valley in Poland, by using the LARCH computer model.

The Vistula River is the biggest river in the Baltic Sea catchment area, that has still retained a semi-natural character for most of its length and is considered to be one of most valuable rivers in Western and Central Europe. The Vistula floodplain area represents an extensively managed landscape, with high nature values and biodiversity. It forms an important ecological corridor for animals and plants connecting southern and northern parts of the Central European Lowland. The diverse structure of the river valley is reflected in high habitat diversity and with over 1010 vascular plant species, representing 40% of Polish vascular plants and including 46 species under strict protection (Załuski 1998). Large forests and extensively used meadows provide habitats to species with large home ranges and dispersion ranges, e.g. Black stork *Ciconia nigra*, and Elk *Alces alces.*

Presently the Vistula river basin is exposed to various environmental stresses including hydro-technical measures aimed at flood control and water transport, water pollution and loss in biodiversity due to development and intensification in use of agricultural lands.

The research area covers a part of the Vistula floodplain in the center of Poland with an area of about 1545sq km, from the Warsaw to Włocławek, a length of 135 km and a width ranging from 20 to 6 km. The area includes core areas and ecological corridors of the national network and is therefore very important for nature protection. Kampinos National Park is the largest protected territory in the study area. It was established to protect rare inland dunes with pine forest and vast wetlands below the dunes covered with natural alder forests or fens.

The VEDI project is a joint cooperation between two institutes from Poland: the Center for Ecological Research PAN and the Institute of Geography and Spatial Organisation PAN; and two institutions from the Netherlands: the Government Service for Land and Water Management (DLG) of the Ministry of Agriculture, Nature and Food Security, and Alterra, which has pioneered the LARCH model. The VEDI project approach has been to develop 5 different scenarios, and simulate the impacts of the corresponding changes in land-use on indicator species (key species). The main environmental threats and opportunities were established in a two-day workshop with (senior) government officials from all levels (national, provincial and local) as well as representatives of NGOs attending. Next, key species relevant to the project area were selected for the computer LARCH model.

Methods

Method of modelling

The landscape-ecological model LARCH (Landscape ecological Analysis and Rules for the Configuration of Habitat), and LARCH-SCAN (Spatial Cohesion Analysis of Networks) developed at ALTERRA, were applied to assess the viability of metapopulations in a fragmented environment, and the spatial cohesion of potential habitats. LARCH provides information on the metapopulation structure and population viability in relation to habitat distribution and carrying capacity. LARCH-SCAN assesses spatial cohesion of potential habitat, and provides information on the best ecological corridors in the landscape.

LARCH is designed as an expert system, used for scenario analysis and policy evaluation. The model has been fully described elsewhere (Pouwels *et al.*, 2002, Groot Bruinderink *et al.*, 2003, Chardon *et al.*, 2000, Verboom *et al.*, 2001, Van der Sluis *et al.*, 2001, 2003, 2004).

The principles of LARCH are simple: a species is selected, relevant for nature conservation or an indicator species representing a suite of species, to assess the natural areas. The size of a natural area (habitat patch) determines the potential number of individuals of a specific species it can contain. The distance to neighboring areas determines whether it belongs to a network for the species. The carrying capacity of the network determines whether it can contain a viable population. If that is the case, the network population is viable or sustainable for the species.

LARCH requires input in the form of habitat data (e.g. a vegetation or land use map) and ecological parameters (e.g. home range, dispersal distance, carrying capacity for all habitat types). In the VEDI project digital vegetation map prepared at a working scale 1:25000 (Matuszkiewicz, Solon 1998) and additional topographical maps were used. The indicator species parameters provided for the modeling were based on literature and expert knowledge. The model outputs were calibrated for the present situation and the same parameters were used for assessment of all scenarios..

Indicator species

Based on a number of criteria a selection of species for analysis was made:

Species should not be too rare, not too common, and ecologically relevant

Species should preferably have been analysed before with LARCH

The scale of the species (home-range) should be relevant for the scale of the area

Based on these criteria 16 species were selected for analysis with LARCH (Table 1). The selected species form target species for local policy, or are representative for the different ecosystems analysed. The species selected differ in their habitat requirements and dispersal range. Some species have a very limited range, of less than a kilometer, whereas large birds might have a range of 50 km or more. Similarly for habitat requirements for a key population: dragonflies will persist in a small area, containing few ponds, whereas a Black stork requires extended areas for foraging. Terrestrial species are usually sensitive to barriers like roads and rivers.

Table 1: Selected species for LARCH analysis

Priority habitat type	**English name**	**Scientific name**
Steep banks	Kingfisher	*Alcedo atthis*
	Sand martin	*Riparia riparia*
Sand banks	Little ringed plover	*Charadrius dubius*
	Little tern	*Sterna albifrons*
Semiaquatic	Great crested newt	*Triturus cristatus*
	Banded demoiselle	*Calopteryx splendens*
	Beaver	*Castor fiber*
Forests	Bank vole	*Clethrionomys glareolus*
	Pine marten	*Martes martes*
	Middle spotted woodpecker	*Dendrocopus medius*
	Elk	*Alces alces*
	Black stork	*Ciconia nigra*
Meadows	Sand lizard	*Lacerta agilis*
	Common root vole	*Microtus oeconomus*
	Large copper	*Lycaena dispar*
	Corncrake	*Crex crex*

Development scenarios

Five scenarios for hypothetical development of the study area were developed in consultation with various stakeholders during a two-day workshop in May 2004. Detailed maps were prepared for each of the developed scenarios, which outlined the changes on the vegetation, hydro technical regulation of the Vistula river, the network of roads in the study area. A review of the LARCH model outputs has shown very limited effects of two scenarios (Scenario 2: Medium intensity regulation and Scenario 4: Restoration and protection of meadows and pastures) and thus only results for remainig three scenarios are presented:

Scenario 1: Maximum river regulation and infrastructure development
Construction of a new dam; removal of all trees in the river area inside of the dikes; and development of other infrastructure like roads, dikes, motorway etc.

Scenario 3: "Brave Vision" for nature protection
Removal of some of the dikes (where possible); removal of the present dam at Włocławek; and removal of some of the settlements in the river valley

Scenario 5: Reforestation
Conversion of low-productivity agricultural fields into forest plantations and natural forest succession

Results

Based on the results of this study it is concluded that at present the fragmentation of the area holds no threat to the favourable conservation status of most of the species assessed. Most of the species have nearly sustainable, sustainable or highly sustainable networks that hold key and Minimum Viable populations, as illustrated for the Pine marten (Fig. 1).

The modelling results show that scenario 1 "Maximum river regulation and infrastructure development", has a pronounced effect in comparison to the present situation, in particular on the species dependent on steep banks and sandbanks (Fig. 2). The scenario results not only in a strong decrease in numbers, it also changes the viability of these small populations. Except for the Sand martin the viability of the population reach a critical level, i.e. long term viability is not guaranteed anymore.

Also species of semi-aquatic and forest habitats are affected but to a limited extent. There is a decrease in population number but not in viability of the overall population. The most marked decrease is shown in case of the Beaver which is due to destruction of its habitats. From one large population it changes into small and fragmented local populations (Fig. 3). However the population does not come in the "danger zone", since sufficient habitat is left, also away from the river. Effects on other species and habitats seem

negligible at the regional scale, although locally marked changes will occur, where e.g. riparian forest disappear or new roads are constructed.

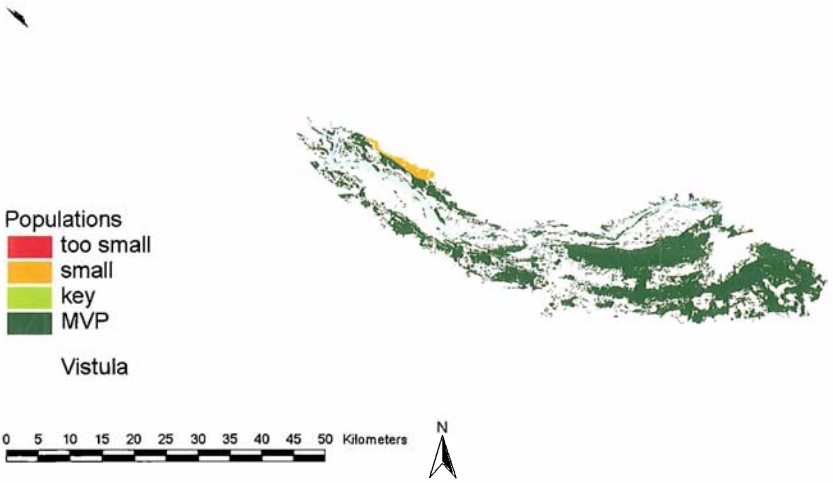

Fig. 1: Potential local populations of the Pine marten in the Vistula Valley based on LARCH modelling.

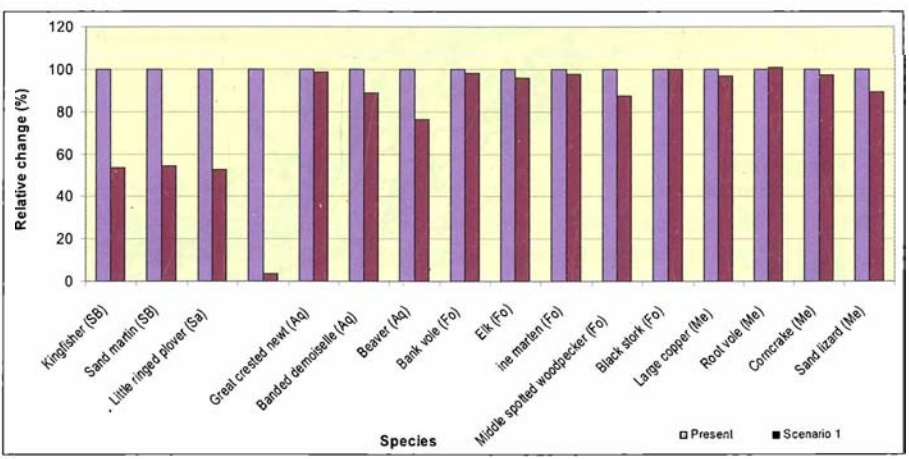

Fig. 2: Relative change of population size (number of reproductive units) of modelled species in scenario 1 and present situation (LARCH results).

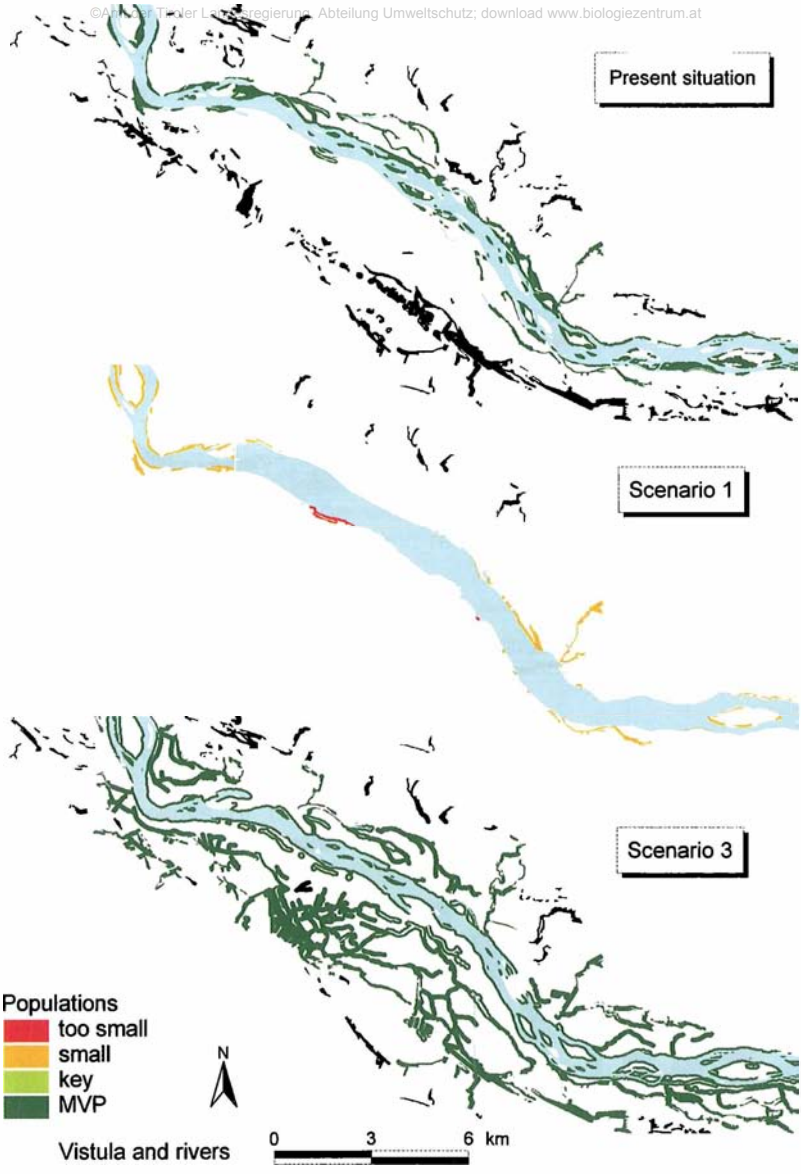

Fig. 3: Potential local populations of the Beaver in the Vistula Valley; present situation and scenario 1 and 3 (area near Płock), based on LARCH modelling.

Scenario 3 “Renaturalisation” affects most of the selected species positively, especially the species of steep banks and sandbanks (Fig. 4). Improvements are in particular important for the species dependent on sandbanks and islands. The connectivity increases much for a species like the Little ringed plover and this part of the Vistula river would form a network due to removal of the dam. Similarly the Little tern population becomes highly sustainable due to these changes. Also semi aquatic and forest species benefit. Several of them like the Great crested newt, Beaver (Fig. 3), Pine marten and Middle spotted woodpecker become highly sustainable in the whole of the area and change mostly to Minimum Viable populations. However a more ambivalent picture is presented by the species of meadows: some of them benefit from the “brave” vision of nature but other species, like the Corncrake (Fig. 5) and Sand lizard, mostly dependent on open and more intensively used landscapes, decline.

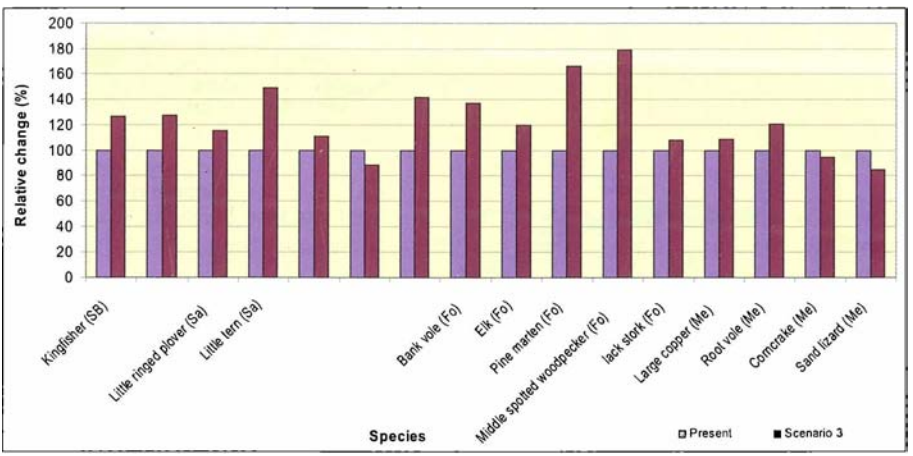

Fig. 4: Relative change of population size (number of reproductive units) of modelled species in scenario 3 and present situation (LARCH results).

Scenario 5 “Reforestation” logically positively influences the species dependent on forest habitat (Fig. 6). A positive effect is in particular noted for the Black stork, which shows a potential increase of population size of appr. 20 %, which results in a so called ‘ Minimum Viable Population’ Some of the species typical for meadows like Sand lizard, Corncrake and Large copper show a decrease as a result of the conversion of arable fields and grasslands.

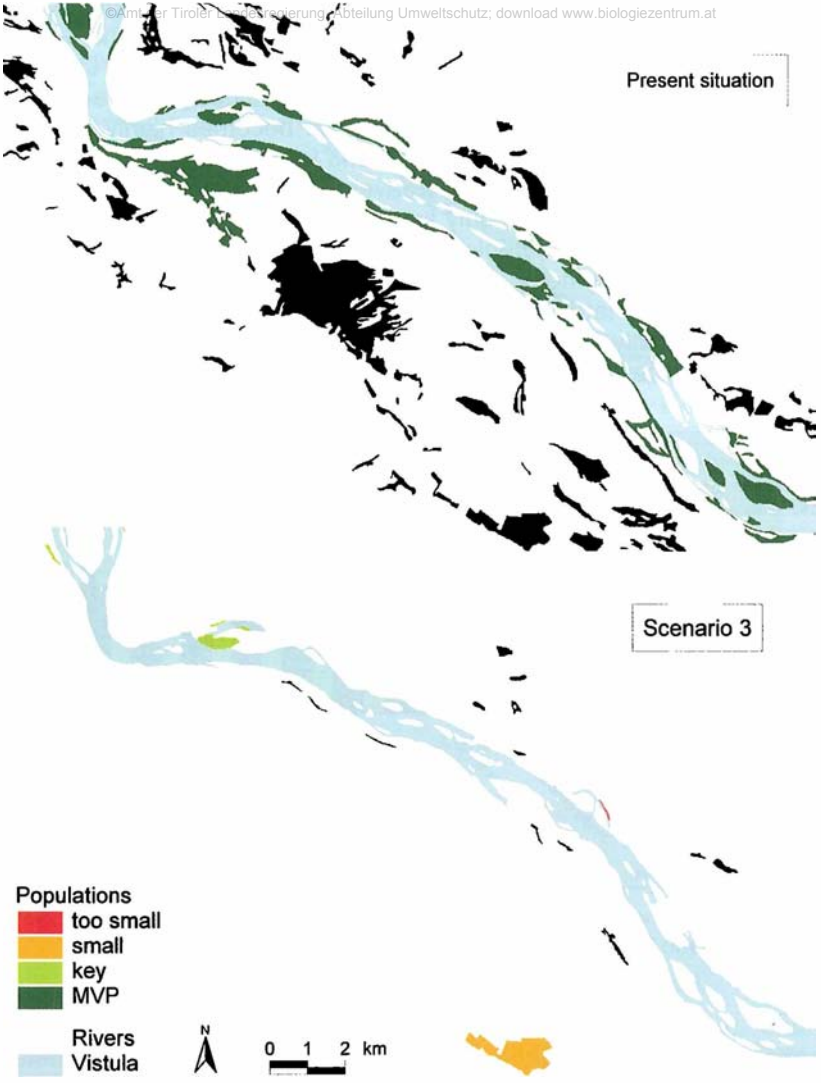

Fig.5: Potential local populations of the Corncrake in the Vistula Valley; present situation and scenario 3 (area near Płock), based on LARCH modelling.

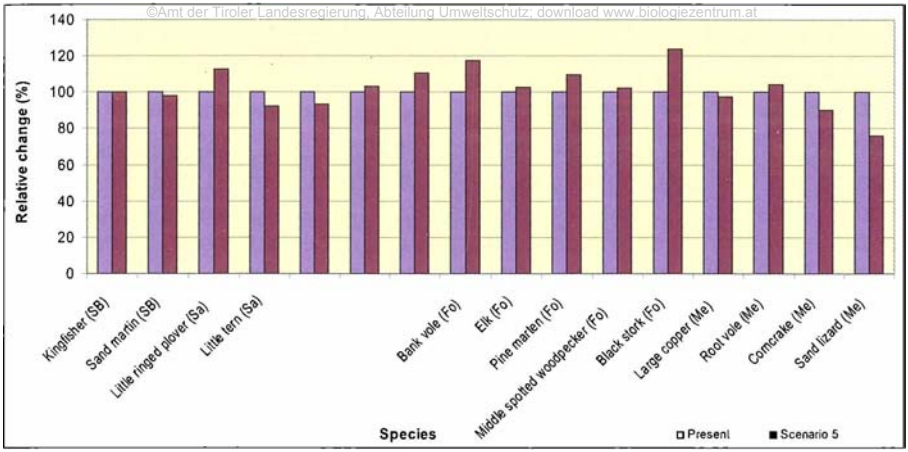

Figure 6: Relative change of population size (number of reproductive units) of modelled species in scenario 5 and present situation (LARCH results).

Discussion

The study area is representative for the general rule of Ecological Network EECONET – Poland (Liro et al., 1995) in a way that it ensures connection between core areas (Kampinos National Park) via ecological corridors (Vistula floodplain) to the remaining National and European Network. The results of the study indicate that at present most of the analyzed species form thriving local populations arranged in sustainable networks (for details see Romanowski et all 2005). The LARCH scan analysis identifies good connectivity of habitats for forest and semiaquatic species like the Middle spotted woodpecker, Bank vole and Beaver.

The analysis conducted for the 16 fauna species characteristic for the main Vistula valley habitats shows potential threats of the infrastructure development reflected in scenario 1 "Maximum river regulation and infrastructure development" (Romanowski et all 2005). The results provide additional indications of the effects of possible measures on two Natura 2000 areas designated in the study area. The changes in the regulation of the river (scenario 1) will have a profound effect on the bird species of the Dolina Środkowej Wisły – Middle Vistula valley area. The effects of scenario 1 on both Natura 2000 habitats and species of the Kampinos National Park is mostly absent due to existing protection of this large area. It is likely that future plans for large-scale water regulation will be in conflict with the protection of the Middle Vistula valley area. As plans are only allowed if they have no significant effect on the area the designation of the area as Natura 2000 site has strongly reduced the options for building dams in the area.

An evaluation of developments that affect the biodiversity and spatial cohesion (fragmentation) of habitats is essential to come to balanced developments, taking into account both environmental and societal needs.

Stakeholder involvement and scenario modelling should be widely used in the process of decision making for spatial development (participatory spatial planning), in particular in Poland where many spatial developments take place now and in the near future.

Ecological modelling is a powerful tool in the decision making process. The discussions with stakeholders in the VEDI-project showed that the LARCH model proved to be a practical tool especially on a regional and local scale for the evaluation of ecological consequences of developments in the Vistula valley. Ecological modelling can be used to evaluate and to improve ecological corridors in Mazovia or the whole of Poland. It was recommended that modelling should be applied in the decision making process regarding all spatial developments that concern Natura 2000 areas, also as a proper evaluation tool to meet EU-requirements in regard of Environmental Impact Assesments.

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