9.2 Effects on terrestrial ecology

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9.2.1 Introduction

As indicated in Chapter 7 the present area of wet and very moist riverine grasslands is very limited, as a result of intensified farming and changes in land use and water management. Therefore the present situation is not very suited to be used as a reference for the effects of climatic change. Instead, a hypothetical reference situation has been used (scenario *EhsBuf_His*, with current climate, see section 2.2). In this reference the plans for the enlargement of the area of nature areas[3] have been implemented, and the water management in and around the nature conservation areas has been adapted to create conditions more favorable for the realization of wet mesotrophic grasslands. In order to put the effects of climate change into perspective, the effects of land- and watermanagement measures are discussed first in the following section. Subsequently, in Sections 9.2.3, 9.2.4 and 9.2.5 the predicted effects of climate change are elaborated upon.

9.2.2 Effects of management measures

Figure 9.8 shows the effects of changes in nature management and water management on riverine grasslands. The effects are presented in terms of changes in the area of wet to moist (mesotrophic) riverine grasslands. For the definition of the riverine grassland types see Table 7.7. The blockdiagram to the left (*Cur_His*) gives the (predicted) area of wet and moist riverine grasslands in the Beerze-Reusel area in the current nature conservation areas. As already mentioned in Section 2 the area of these grasslands, which are the most interesting from a nature conservation viewpoint, is very limited (see Figure 9.9 for their present distribution). The area predicted with NATLES is 63 ha (15+48), which may even be an overestimation of the present area. In the near future the area under nature management is expected to strongly increase with the realization of the National Ecological Network (EHS).

[3] The realisation of the so-called National Ecological Network, according to the plan by the Ministry of Agriculture, Nature and Fishery, 1990; in this report the National Ecological Network is referred to as the 'EHS', using the Dutch abbreviation.

The second blockdiagram in Figure 9.8 shows an increase in wet and very moist riverine grasslands from 63 to 163 ha (53+110) owing to the increase of areas under nature protection, assuming that no changes in water management occur, neither within the areas or outside of them.

The latter assumptions are rather unrealistic, as the present water management has been tuned to maximizing agricultural production. Because nature management aims at increasing the area of wet riverine grasslands, measures will no doubt be taken that are aimed at raising the surface water levels and watertables. Reduced drainage within the EHS areas in scenario *Ehs_His* is expected to increase the surface area of wet and very moist riverine grasslands from 163 to 219 ha (219=81+138, Figure 9.8).

Figure 9.8 Effects of changes in nature management and surface water management on the area (ha) of wet and moist riverine grasslands.

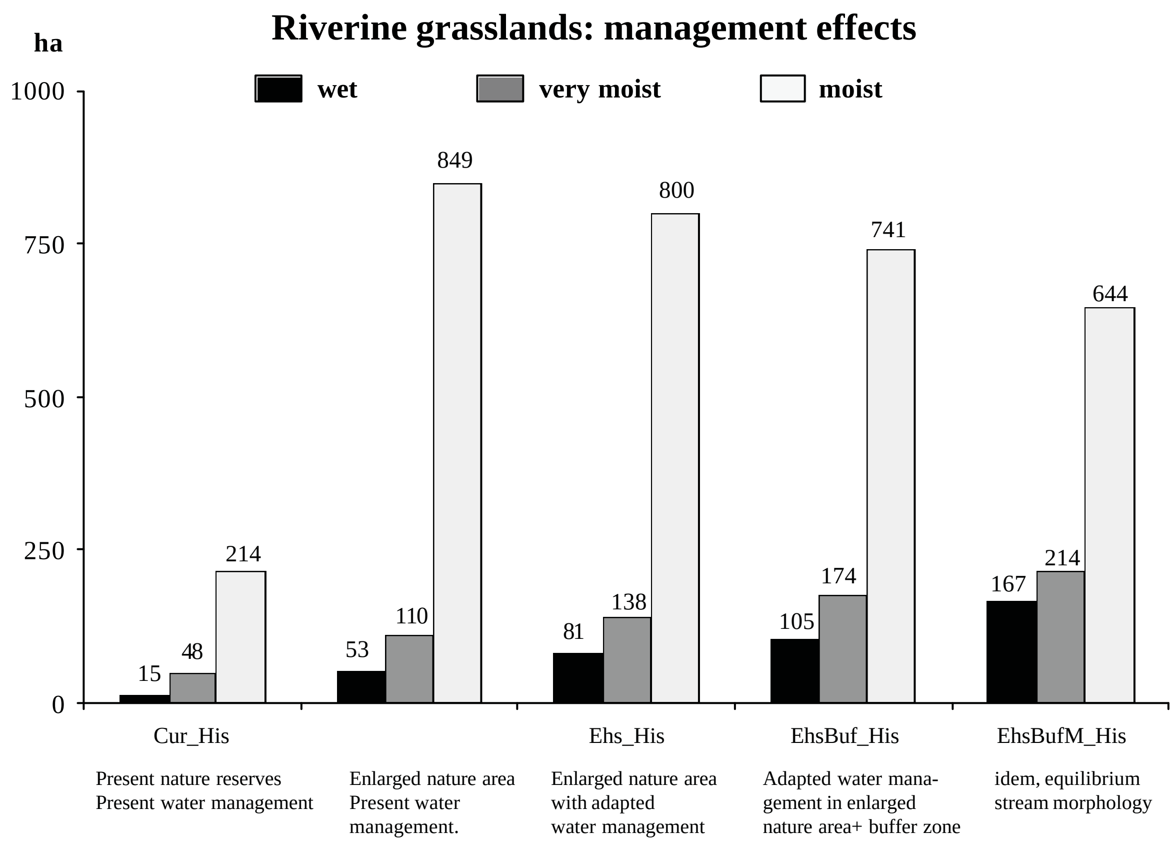
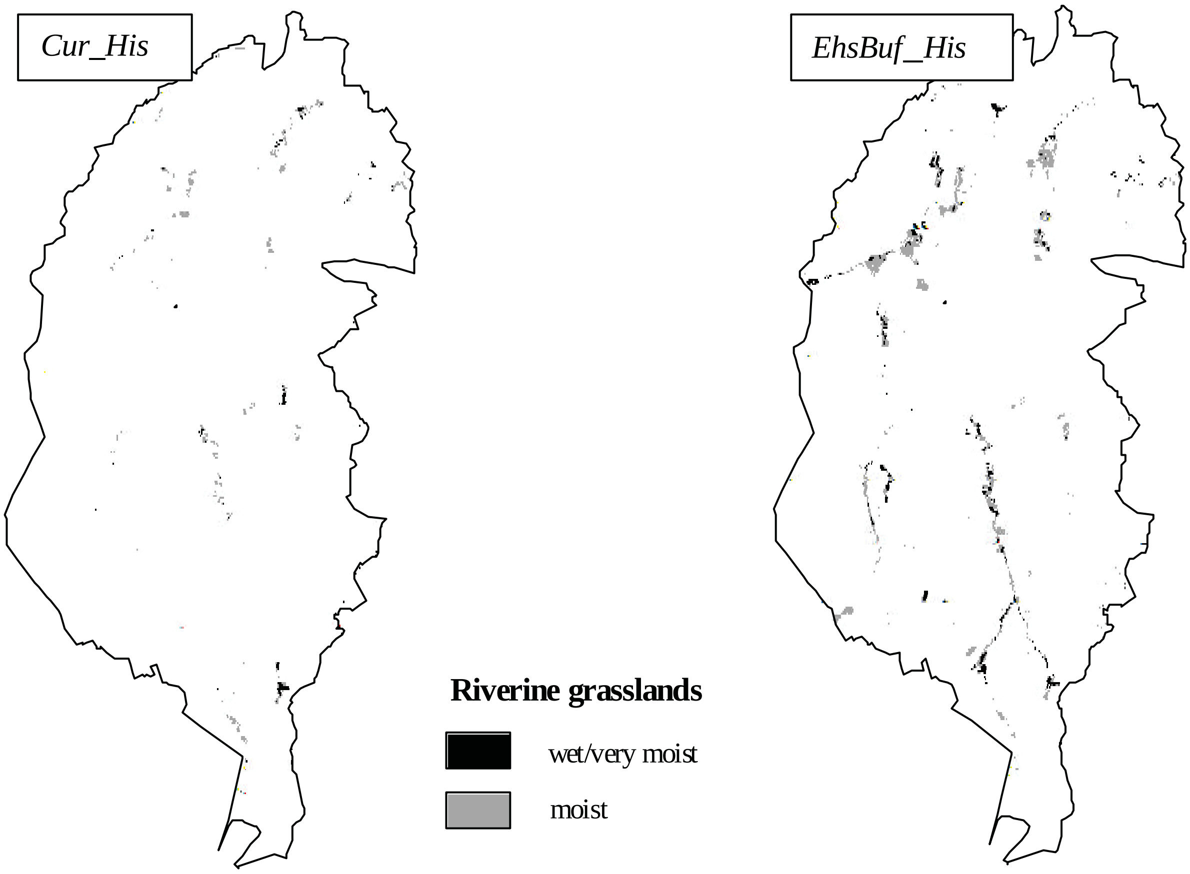
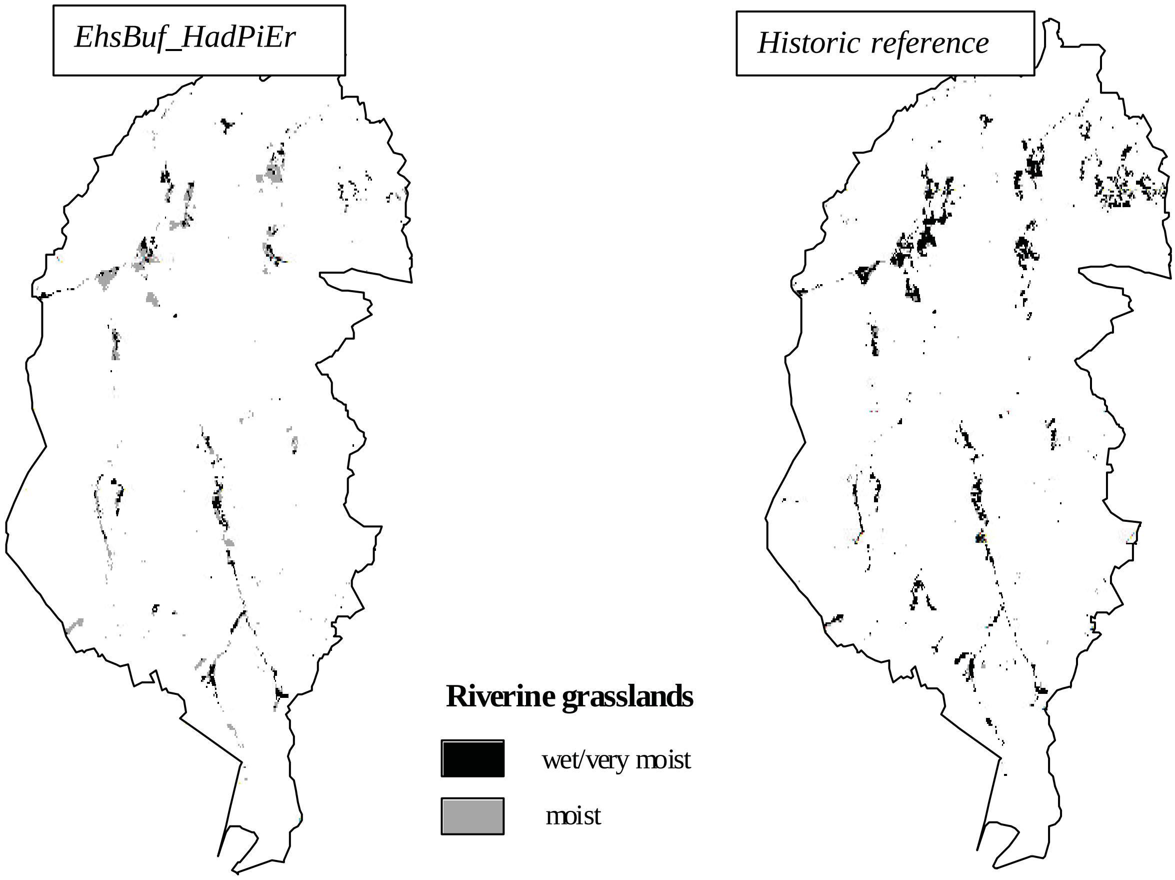


Figure 9.9 Impact of nature conservation measures. To the left the predicted distribution of wet and moist riverine grasslands with present hydrology and present nature conservation areas. To the right predicted situation after realization of the National Ecological Network and with adapted water management in and around nature conservation areas



Reduced drainage in a buffer zone around the EHS nature reserves will result in an additional increase with 70 ha, to 279 ha (*EhsBuf_His*, 279=105+174,see Figure 9.8 and also Figure 9.9 for the spatial distribution). The largest increase in the area of wet and very moist riverine grasslands can be achieved when additionally sedimentation and erosion processes are allowed to bring about a new river morphology, that is in equilibrium with the river discharge (*EhsBufM_His*). Because of the decreased river depth in this situation the draining effect on the adjoining riverine grasslands will decrease. The result is an additional increase with 102 ha, to 381 ha (167+214, see Figure 9.8).

Figure 9.10 Distribution of wet and moist riverine grasslands in the wettest scenario (*EhsBuf_HadPiEr*, see Section 9.2), compared with that in a scenario with historic hydrology as estimated by Van Ek et al. (1997) on the basis of soil characteristics and relief.



To get an impression of the impact of man-induced changes a calculation was made for a situation with a historic reference hydrology, as estimated by Van Ek *et al.* (1997) on the basis of soil type, relief and historical land use (Table 9.3, Figure 9.10). In the historic reference situation according to Van Ek et al. wet riverine grasslands prevail (MSW 0-25 cm below soil surface), whereas in the other scenarios, even with adapted water management and with the wettest climate scenario (*EhsBuf_HadPiEr* in Figure 9.10), moist grasslands are most common (MSW > 40 cm below soil surface). Reasons for this discrepancy may be that (1) Van Ek *et al.* have overestimated the area of wet upward seepage areas, or (2) that in this study the drainage in the scenarios with adapted water management is still more intensive than in the past situation, or (3) that deep extraction wells in the northern half of the study region have a strong effect. These wells were not present in the historic situation, or only with a much smaller extraction rate. The latter explanation (3) is thought to be the most likely one.

Table 9.3 Area of wet and very moist riverine grasslands with present hydrology, compared with situation with reference hydrology as estimated by Van Ek *et al*. 1997.

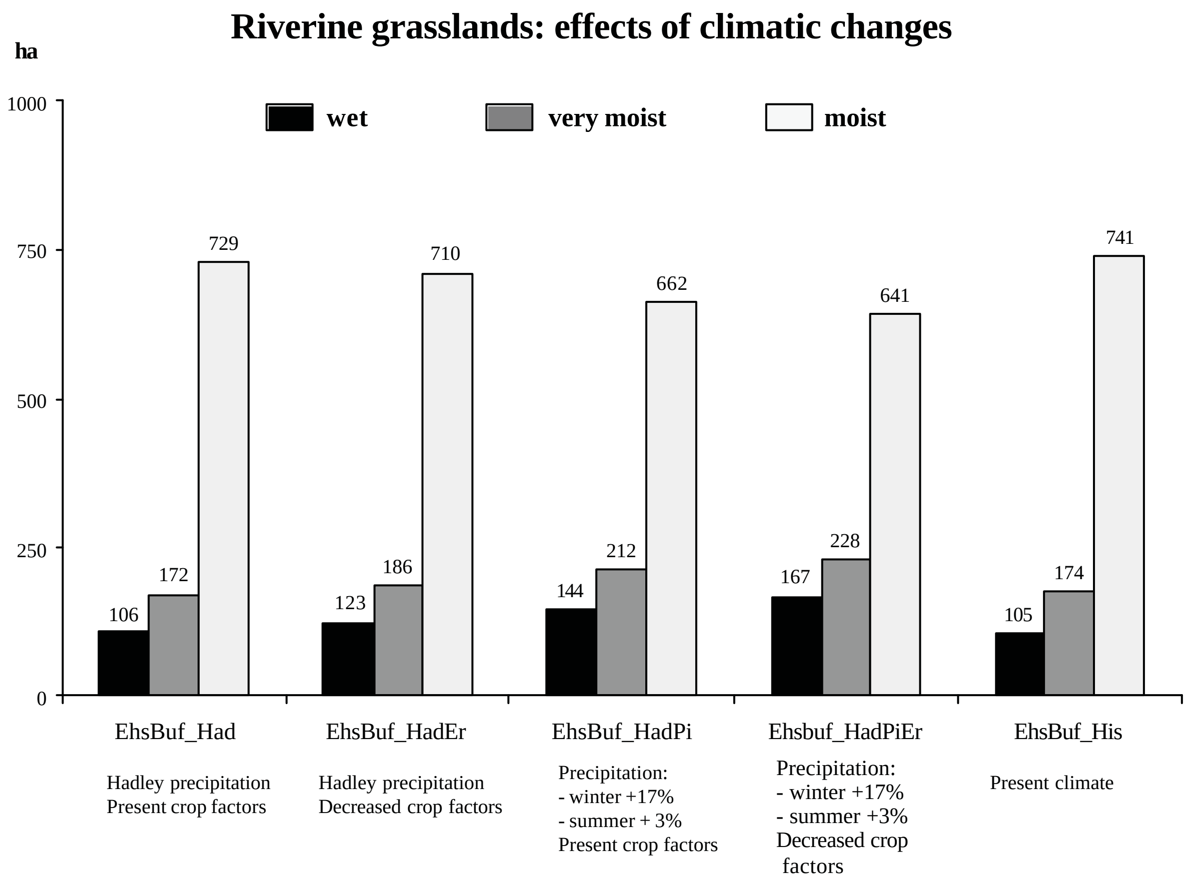
	present nature area	planned nature area (EHS)
present hydrology	63	163
reference hydrology	-	1200

9.2.3 Effects of climate change on areas of wet riverine grasslands

Figure 9.11 shows the effects of changes in climatic conditions on the area of wet and dry riverine grasslands. For comparison purposes the effects of changes in climatic conditions on the area of wet and dry heath is shown in Figure 9.12. The situation in which the EHS has been realized and drainage in the EHS and surrounding buffer zones has been reduced (*EhsBuf_His*) is used as a reference situation for the present climate (diagram on the far right). The first two diagrams show the changes in the area of riverine grasslands under the Hadley climate scenario (*EhsBuf_Had* and *EhsBuf_HadEr,* the former with present crop factors, the latter with decreased ones). The next two diagrams show the changes in the area of riverine grasslands under the scenarios *EhsBuf_HadPi* and *EhsBuf_HadPiEr* in which the temperature increase is equal to that in the Hadley scenario, but the annual precipitation increases more strongly (17% increase in the winter; see Section 2.2).

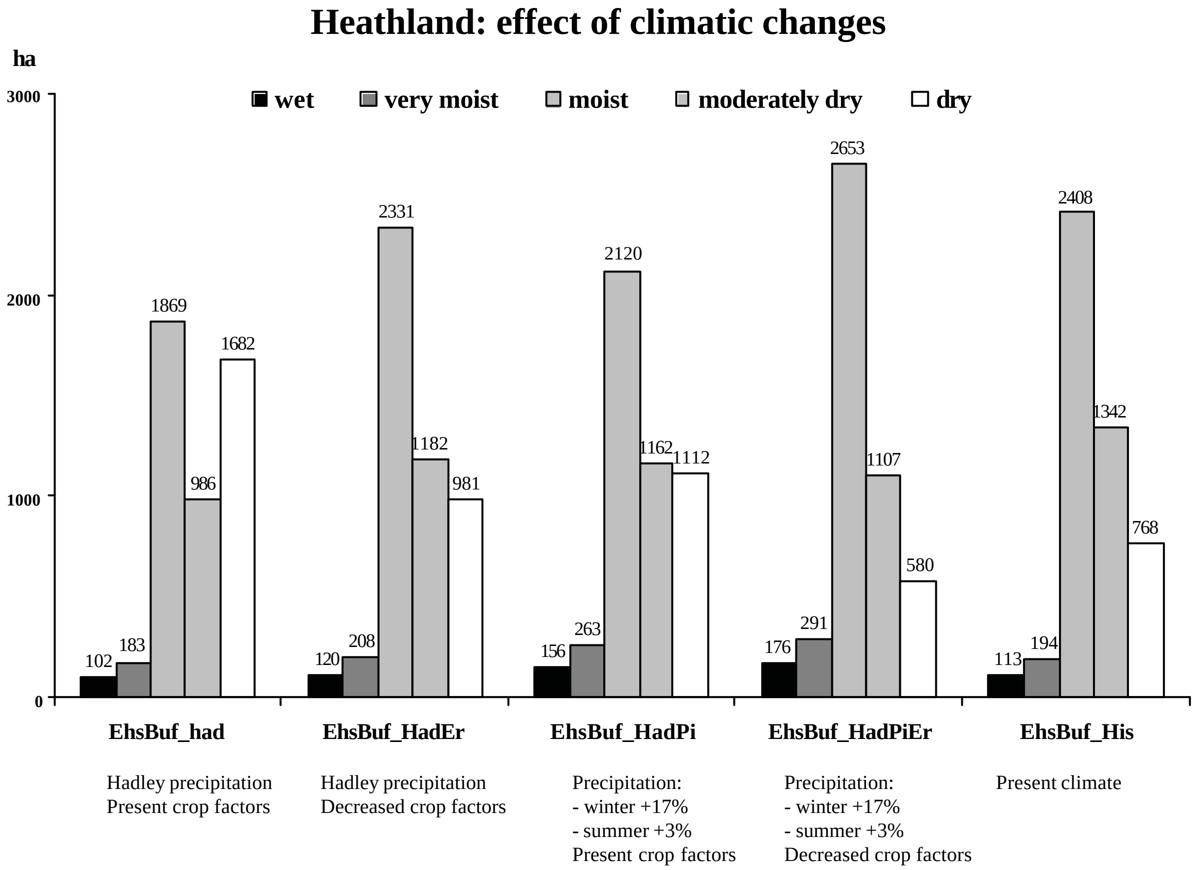
Under the Hadley scenario when no changes in crop factors are assumed (*EhsBuf_Had*) the precipitation excess will decrease. In the upland infiltration areas there are substantial shifts in moisture regime, resulting in a shift from moist to dry heathlands (Figure 9.12). Dry heath increases by 119 % from 768 to 1682 ha. This is caused by lower summer watertables, which causes more moisture stress for the vegetation. Compared to the effects on the upland infiltration areas, the effects on wet riverine grasslands are moderate. The *EhsBuf_Had* scenario hardly differs from the reference situation *EhsBuf_His*: the area of wet riverine grassland is predicted to be 105 ha in the former and 106 ha in the latter.

Figure 9.11 Effects of changes in climatic conditions on the of area of wet and moist riverine grasslands.



In the situation that the crop factors are reduced because of the decreased transpiration under CO_2-rich conditions (*EhsBuf_HadEr*) the precipitation excess increases. In 'wet' parts of the the infiltration areas there is a slight increase in the area of wet heathland (+ 6%, from 113 to 120 ha), but also a more pronounced increase in the area of dry heathland (+18%, from 768 to 981 ha). All in all, this scenario leads to a more pronounced contrast in the infiltration areas between wet and dry situations, and a decrease in the area of moist heathland. The effect of decreased crop factors in *EhsBuf_HadEr* on the relative areas of wet, moist and dry riverine grasslands are moderate but not insignificant: the area of wet riverine increases from 105 to 123 ha.

Figure 9.12 Effects of changes in climatic conditions on the of area of wet and dry heath



In the infiltration areas the contrast between wet and dry situations increases in a most pronounced manner in the *EhsBuf_HadPi* scenario. In this scenario the winters are much wetter because of increased precipitation, while in summer the increased temperature leads to increased evaporation. In this scenario both wet and dry heathlands increase in size (from 113 to 156 ha and from 768 to 1112 ha, respectively), whereas the area of moist and moderately dry heathland decrease from respectively 2408 and 1342 ha to respectively 2120 and 1162 ha (Fig. 9.12). In the riverine grasslands the effects of this climate scenario are less pronounced (Fig. 9.11). The total area of wet and moist riverine grasslands remains the same, but there is a shift towards wet grasslands (an increase of the latter from 105 to 144 ha).

The *EhsBuf_HadPiEr* is by far the 'wettest' scenario as in this scenario the precipitation strongly increases, whereas the evaporation hardly increases because of lower crop factors. In the infiltration areas this is accompanied by a shift from dry and moderately dry heathland to moist heathland (e.g. a decrease from 768 to 580 ha for dry heathland and an increase from 2408 to 2653 ha for moist heathland). The area of wet riverine grasslands and wet heathlands increases significantly. In the river valleys there is a similar shift from moist grasslands (-100 ha) towards wet and very moist grasslands (+116 ha)(Figure 9.11).

The total area of wet, very moist and moist riverine grasslands is more or less the same in all scenarios (1020 ha), the largest changes being a 1% decrease in the driest scenario *EhsBuf_Had*. This is seemingly in conflict with the observation in Section 8.2 that in the climatic scenarios *Cur_Had* and *Cur_HadPi* there is a strong increase in the area with upward seepage. In climate scenario *Cur_HadPi*, with increased precipitation, an increase in the area of mesotrophic riverine grasslands was expected, due to the buffering effects of bicarbonate-rich groundwater. An analysis of the results shows two reasons why in scenario *EhsBuf_HadPi* the area of wet and moist riverine grasslands nevertheless remains the same. In the first place, the increase in upward seepage is to a large extent situated in places with non-calcareous groundwater according to the data of Van Ek *et al.* (1998), so that increased seepage does not result in increased buffering. In an additional scenario, in which all groundwater in the study area is assumed to be bicarbonate-rich, there is an increase in the area of wet and moist riverine grasslands due to the increase in seepage (Table 9.4, second column). However, the increase is relatively small (+3%). This is caused by the fact that increase in upward seepage often occurs in mineral-rich river valley soils, which are already buffered or have a higher base saturation and are only weakly acidic. In these places increased seepage does not lead to changes in ecosystem type (wet and moist riverine grasslands). A much stronger effect can be expected in situations where groundwater is uniformly bicarbonate-rich and in which all soils are non-calcareous. In that scenario the increase in the

Table 9.4 Area of wet and moist riverine grasslands (ha) in the scenarios *EhsBuf_His* and *EhsBuf_HadPi* compared with situations in which (a) groundwater in the whole study area is assumed to be bicarbonate-rich, and (b) groundwater is assumed to be uniform bicarbonate-rich and all soils are assumed to be non-calcareous.

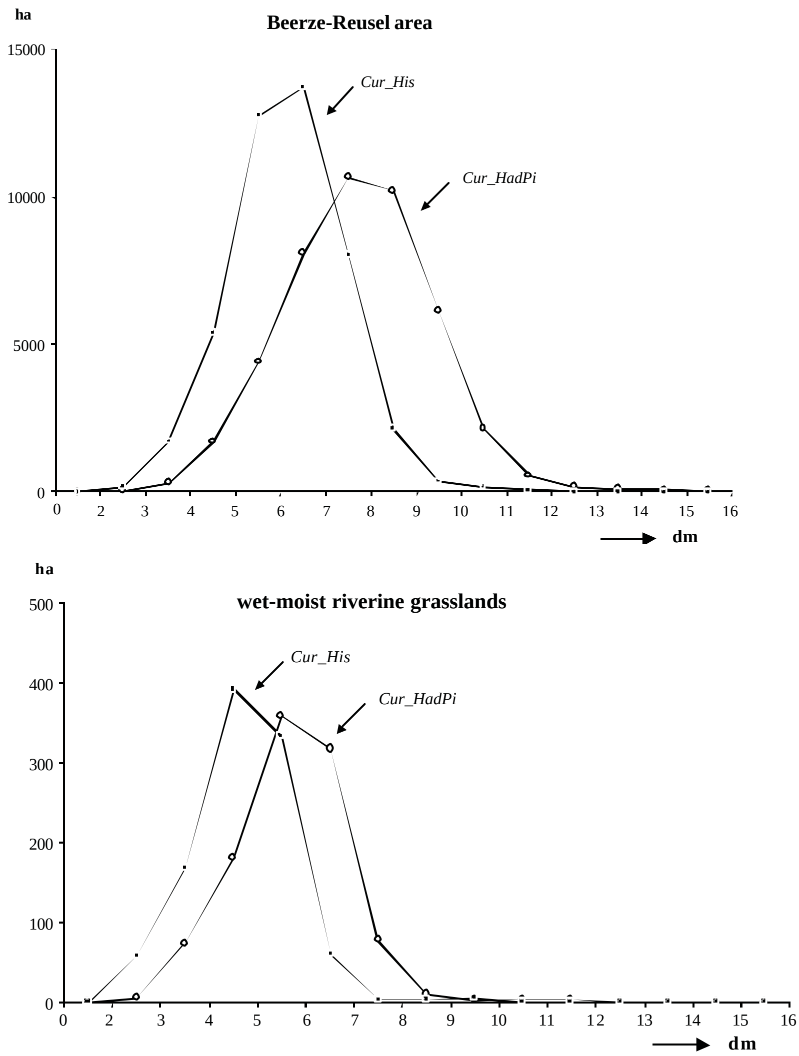
Scenario:	standard scenarios (*EhsBuf_His* and *_HadPi*)	bicarbonate-rich groundwater (a)	bicarbonate-rich groundwater, non-calcareous soils (b)
EhsBuf_His	1020	1052	343
EhsBuf_HadPi	1018	1079	405

area of wet and moist riverine grasslands is more or less in line with the increase in upward seepage (an increase with 18%, see Table 9.4, third column). In the long term the increase in upward seepage in these soils may form an efficient buffer against the decalcification that will occur under infiltration conditions. The *buffering* capacities of the soils are *over*estimated in NATLES. In this model, soil acidity is predicted for present soil types for a period of 10-30 years. In this study predictions are made for a much longer period (about 80 years), in which leaching may lead to a lower buffering capacity of the soil. Therefore buffering with bicarbonate-rich groundwater may become even more important than in the present situation.

9.2.4 Effects of climate change on moisture dynamics

As indicated in Section 7.2, dynamic situations in which both pronounced anaerobic periods and periods with moisture stress occur on the same site are very rare in the present climate. However, the climatic changes may result in more extreme situations. This is most likely to occur in the climate scenario *Cur_HadPi*, in which both the winter precipitation and the summer evaporation increase (downscaled Hadley scenario, and increased precipitation by KNMI rule-of-thumb). In this scenario the watertable fluctuations increase, with about 0.2m in the whole area, and about 0.1m in wet and moist riverine grasslands (Figure 9.13). A hypothesis in this study was that a new and more dynamic habitat might come into existence, with both anaerobic conditions due to high groundwater levels in winter and drought stress in summer due to lower groundwater levels in summer and increased evaporation. However, this turns out to hardly be the case. Table 9.5 shows that even in the climate scenario *HadPi* moisture stress is not expected to occur in the wet and very moist riverine grassland. Only in the heathland vegetations there is a small increase in wet and very moist heath with little or moderate moisture stress (respectively 3-13 days and 14-30 days with a soil water potential less than -12m). Wet and very moist sites with large moisture stress (>30 days with a soil water potential less than -12m) are absent in both the present and the predicted situation.

Figure 9.13 Groundwater fluctuation (difference between Mean Spring Watertable and Mean Lowest Watertable) in the current climate and in the climate scenario *Cur_HadPi*. Hectares per groundwater fluctuation class. Above: groundwater fluctuations in the whole study area. Below: groundwater fluctuations in wet and moist riverine grasslands only.



In the calculation of the moisture stress in the climate scenarios use is made of repro-functions, calculated with the SWAP model, that may be less accurate in extreme climatic situations (see Section 5.3). As a check, in the Smalbroeken area direct calculations of the moisture stress were made with the SWAP model, using the precipitation and evaporation from the climatic data, the groundwater levels and the hydraulic head from SIMGRO simulations. Calculations were made for 12 points in a sequence trough the river valley. The outcome was in line with the results mentioned above. Although evaporation is much larger in the *EhsBuf_HadPi* scenario than in the present situation, moisture supply is still sufficient and except for extreme years moisture tension in the wettest parts never falls under a critical level of -12 m.

Table 9.5 Increase (in ha) of wet and very moist sites with moisture stress in the most dynamic scenario *EhsBuf_HadPi* (wetter in winter and spring due to increased rainfall, dryer in summer due to increased evaporation) compared to the present-climate scenario *EhsBuf_His*.

	EhsBuf_His			***EhsBuf_HadPi***		
	moisture stress			moisture stress		
	none	little	moderate	none	little	moderate
wet riverine grasslands	104	-	-	144	-	-
very moist riverine grasslands	174	-	-	212	-	-
wet heathland	112	1	-	152	4	-
very moist heathland	189	5	0	247	12	4

9.2.5 Conclusions

The effect of climatic changes on the occurrence of wet and very moist riverine grasslands is likely to be small, and in most scenarios positive: in the driest scenario (*EhsBuf_Had*) no change, in the wettest scenario (*EhsBuf_HadPiEr*) an increase with 42% is predicted. Further more, the expected climate changes do not lead to moisture stress in the wet and very moist riverine grasslands. This is connected to the fact that these ecosystems mainly occur in upward seepage areas, which are well buffered against changes in hydrology. Changes in watertable are relatively small, and shortages in moisture supply are not likely to occur as a result of upward seepage. In contrast, in the upland infiltration areas much larger changes in the area of wet and dry heath can be expected, which is linked to the fact that changes in watertables are much larger there.

However, a reservation must be made in regard to the conclusions that wet mesotrophic riverine grasslands are not threatened by the predicted climatic change. In this study no attention was given to the possible effects of increased flooding (Figure 7.1). In itself flooding is no threat for the vegetations that are characteristic for wet and very moist riverine grasslands, or may even have beneficial effects. However, the water of the Beerze and Reusel rivers is very eutrophic. Without changes in water quality increased flooding with river water will undoubtedly result in eutrophication. This might lead to a decrease in wet mesotrophic grasslands, and an increase in species-poor sites of high nutrient availability dominated by *Glyceria fluitans* and other less valued species.