Summary

Scientific studies show that climate change through changes in temperature and precipitation may greatly affect the distribution of species, among which plant species. It is expected that climate will further change in near future. However, it is unclear how this will affect plant species distribution.

In the past, several models have been developed that predict the effect of climate on the vegetation distribution. These models vary from very simple to very complex. The simple models predict vegetation distribution by the abiotic conditions without incorporating a causal relationship between the abiotic drivers and the presence or absence of the species (so-called habitat distribution models; HDMs). In contrast, the complex models describe in detail how plants respond to different abiotic conditions. The high number of parameters needed for the latter category of models makes it impossible to use it for a high number of species. Therefore, to reliably predict the effects of climate change on the vegetation, both models are not appropriate: the simple models lack functional relationships between the environment and the species, while the complex models cannot be parameterized for many species. A model that can predict the effects of climate change ideally combines the strengths both models.

Recent developments in ecology show that plant traits may bridge the gap between simple and complex models. Plant traits are morphological, physiological and phenological characteristics of plants and show how a plant is adapted to local environmental conditions. Examples of plant traits are plant height, rooting depth, leaf area, stem density etc. The advantage of plant traits is that they are (often) easy to measure and at the same time show how plants are adapted to the local conditions. Research shows that there is a strong link between the local environmental conditions and the traits of species at that location.

This thesis investigates whether it is possible to develop a new class of vegetation models in which plant traits are central and as such can bring the desired functionality in HDMs. The rationale of the new model is simple and closely follows the assembly theory: local abiotic conditions put constraints on the traits plant can have to viably grow there. Next, any species that has this suite of traits has a chance to grow there. Compare: a company creates a function profile for a vacancy. The chance that someone gets the job depends on the extent to what his/her skills correspond to the skills required for that job. The model developed in this thesis does not predict the occurrence of single species but of vegetation types (an assemblage of species that co-occur more often than expected by chance) and is applied in the Netherlands, a country with a high information density on abiotic conditions and species assemblages. Since plant traits have not been used before in a predictive framework, there are many unknowns. This thesis investigates four crucial steps that are necessary to develop a model of this kind.

In chapter 2 we investigate which and how many traits are needed to optimally distinguish vegetation types from each other. The chapter shows that vegetation types can...
be separated from each other because they have a different suite of plant traits. Vegetation types can best be distinguished from each other if traits are used that are functionally different, i.e. traits that are indicative of the suite of challenges a plant faces during its lifetime (for example height, leaf nitrogen content and seed mass as indicators for light, soil fertility and disturbance respectively).

Chapter 3 determines to what extent some of the traits used in chapter 2 can be predicted by a combination of disturbance and soil fertility. The relative effect of both drivers on traits is quantified with an advanced statistical technique (structural equation modelling; SEM) which allows statistically modelling cause-effect relationships. The results of the SEM show that most plant traits are affected by both disturbance and soil fertility. On top of that, plant traits that are representative of plant architecture determine to a large extent the value of other traits, due to internal coordination of the plant.

The insights of chapter 2 and 3 are combined in chapter 4 to build a new class of vegetation models. The model consists of two steps: in step 1, four plant traits are predicted by four environmental drivers. In step 2, the probability of a vegetation type to occur is calculated based on its traits. Chapter 4 shows that at the landscape scale the model predictions correspond very well with the observations. However, locally the predicted vegetation type may deviate from the observed vegetation type as multiple vegetation types have a chance to occur given the constraints set by the environment.

The model that is developed in chapter 4 is not time explicit. To investigate if a trait-based model potentially can be transformed into a dynamic (time explicit) model, I investigated as a first step in this direction how plant traits change during succession. Chapter 5 shows, by using chronosequences, that changes in plant traits during succession can be explained by a universal response to changing light conditions and a specific response depending on the initial abiotic conditions.

This thesis shows that plant traits can be successfully used to predict the distribution of vegetation types. The model has a high predictive power if i) traits are used that are functionally different, ii) traits are predicted by multiple environmental drivers, iii) the internal coordination of traits is incorporated and, iv) a limited number of vegetation types is used (10-20). Generally, we conclude that a trait-based HDM is a promising solution for the lack of functionality in conventional HDMs, and this thesis contributes towards the development a new class of HDMs that contain sufficient functionality to be used with confidence in a changing climate.