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An internet-accessible knowledge system on spatial evaluation of the habitat of meadow birds

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Abstract: Effective management for nature conservation needs a basis in scientific research and a careful communication of the knowledge to the workers in the field. This is especially the case in agri-environmental schemes, where nature conservation is to be combined with agricultural production.

The Netherlands form a vital part of the natural habitat of a well-known meadow bird, the black-tailed godwit (*Limosa limosa*). A large portion of the European population is breeding in the Netherlands, but numbers are declining rapidly. Therefore, farmers united in agricultural nature conservation groups formulate management schemes to manage their meadows in a mode which is beneficial for the black-tailed godwit.

For meadow birds there is a long lasting discussion on this subject, with questions like: what are the minimum conditions which have to be fulfilled? What are the possibilities within agriculture and how does this relate to nature reserves? What area is needed to reach the pre-defined goals? The today's view is that a so-called mosaic-management is needed, an alternation of several growth stages and type of use, in space and time.

In practice there is a gap between scientists and workers in the field how an effective mosaic is defined. To bridge this gap, Alterra's experts on meadow birds have used ArcGIS to develop a knowledge system. This knowledge system is a spatially explicit model to assess the effectiveness of management schemes in combination with a web-based user-interface which can be used by members of the agricultural nature conservation groups to enter management schemes. The data collected by this web-site are used as input for the ArcGIS model. The system concentrates on defining suitability of the habitat (excluding management) and on the expected effectivity of management, related tot the survival of chicks.

With the exception of the ArcGIS model, the system could be transferred to organisations which do not have ArcGIS at their disposal. The application of open standards facilitates integration with other GIS software applied by those organizations.

The system consists of a number of components. Representatives of the agricultural nature conservation groups are allowed to log in to the data entry application. This application has been developed using Adobe Flex. It connects to a transactional WFS (open standard describing read-write access to spatial data) to insert and update the information with regard to the management schemes. The open source internet GIS server GeoServer was used as WFS and was connected to a proprietary Oracle Spatial database. To run the proprietary ArcGIS model, data are downloaded from the GeoServer WFS in Shape file format. A direct link between ArcGIS and the rest of the system is not yet fully operational but will be in the near future.

The approach as described above has been successful. The system has been used by agricultural nature conservation groups and has received positive feedback. It became also clear that there is a list of potential improvements. A follow-up on this will strongly improve the application and make it better suited to assist the users in applying management schemes which will be beneficial for the black-tailed godwit.

Keywords: *environmental modelling, GIS, black-tailed godwit, biodiversity, species protection*

1. BACKGROUND

In The Netherlands, fragmentation of (semi)natural ecosystems is regarded as a major nature conservation problem. The current Dutch Nature Conservation Policy Plan proposes a spatial network consisting of existing nature reserves, nature redevelopment areas and corridor zones. One of the objectives is to stop the decline of biodiversity due to fragmentation (Opdam et al., 1995). Numerous studies exist on how to predict the species richness based on landscape fragmentation, habitat cover and diversity (such as Jiguet, 2004) or for the quantitative analysis of the biodiversity of landscapes (Pouwels et al., 2002). These studies do not take into account that, especially for agricultural habitats, the plant cover is seldom static during the breeding season. They do not include the role of specific management measures, which lead to varying suitability for breeding and raising chicks for meadow birds.

The grassland in the Netherlands forms a vital part of the habitat of meadow birds, of which the black-tailed godwit (Limosa limosa, see **Error! Reference source not found.**) is a so called flagship species. Protection of the black-tailed godwit is an important element of Dutch nature policy.

Figure 1. Black-tailed godwit (photo Danny Ellinger).

A large portion of the European godwit population is breeding in the Netherlands (ca 60-80%), but numbers are declining rapidly since black-tailed godwits cannot keep up with changes in the management of grassland to optimise yield for the farmers (Noordwijk et al., 2008, Both et al., 2006). The problem as a result of the changes in management is the diminishing opportunity for the black-tailed godwit to breed and raise chicks: nests are trampled by cattle or damaged while mowing, the availability of food (insects) has diminished and predation of offspring has increased.

In the Netherlands, both nature conservation bodies as well as farmers are involved with management schemes. The farmers, united in agricultural nature conservation groups, formulate management plans to manage their meadows in a mode which is thought to be beneficial for the species and which fits in with the daily conduct of business. This approach, in combination with existing nature reserves, should stop the decline in numbers of the black-tailed godwit, amongst other species, but have not been very effective (Kleijn et al., 2003). The reason for this lack of success could be, that the proposed management plans do not take into consideration the spatial relations and coherency between the measures taken (Melman et al., 2008, Schotman et al., 2005).

The Dutch Department of Agriculture has approached the Dutch organisations which are involved in Nature conservation in rural areas, to produce tools and building blocks to develop new regulations for habitat protection. These regulations should focus on the protection of meadow birds by increasing their reproduction on one side and by decreasing their mortality rate on the other. Key factor is an area based approach instead of focussing on individual farms. As part of this initiative, and subsidized by the Dutch government, the combined organisations have approached Wageningen University Research Centre to develop a tool to check the proposed management schemes both in advance of the breeding season as well as after the breeding season has ended. Starting point was to create a tool which would facilitate the area based approach, by making it possible for farmers within nature conservation groups to work together on the development of a broadly accepted management plan.

Spatial planning proves to be a rather complex process. It was decided to investigate whether an GIS-based knowledge system could be developed to evaluate the success of management schemes and in addition, to support the agricultural nature conservation groups in defining the optimal management scheme for black-tailed godwits. In addition, the system should be internet-based, since this would make it easy to distribute the application, with easy updates, centralized storage of input data and possibility to use ArcGIS on the server without the need to have it installed locally. Starting point was to create a system which would "invite" the practitioners to actually use it, by making it as accessible and simple as possible.

2. METHODS AND MATERIAL

To be able to answer the above mentioned research question, an online GIS support tool was developed which can be used to manage and analyze spatial data regarding meadow birds. The first version was very basic. It was tested in one municipality to see if there was a niche for a system like this.

It turned out that the system was indeed helpful in guiding both the local government as the nature conservations groups in how to increase the suitability of the local landscape for meadow birds such as the Black-tailed godwit. It became clear that a such a system should be introduced as a system which merely only helps to decide what is the best management scheme for meadow birds. Users should be free to decide if they literally follow up the recommendations or if they would like to make adoptions.

The challenges which needed to be addressed in the next versions were the following:

- Adding more in-depth knowledge, in more detail, to the existing application
- Broadening the applicability for other species then the Black-tailed Godwit
- Raising new research questions
- Addressing the needs of users and increase usability
- Introducing the latest ICT-possibilities

This newly created system consists of a number of components.

Figure 2 provides an overview how the different components relate to each other.

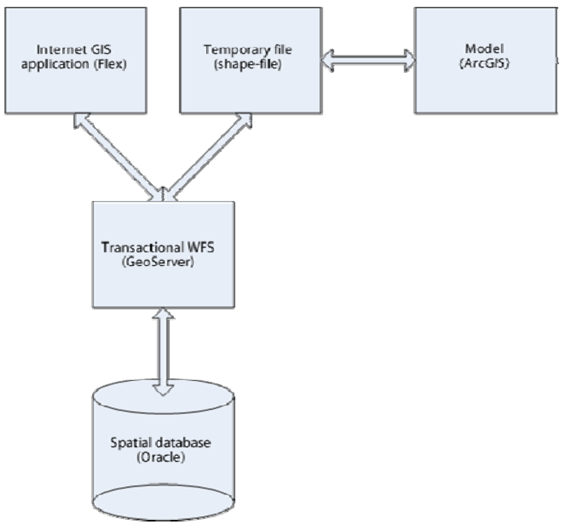

Figure 2. Components of the system (Vanmeulebrouk, 2008).

Representatives of the agricultural nature conservation groups are able to log in to an internet GIS application (Figure 3). This data entry application was based on a framework for web based internet GIS applications, dubbed Luigi (Vanmeulebrouk et al., 2008). This framework is based on Open Standards as defined by the Open Geospatial Consortium. The OGC standards applied in this particular application are the Web Map Service (WMS) standard, which produces maps with geo-referenced data (Open Geospatial Consortium Inc., 2004) and the Transactional Web Feature Service (WFS-T), standard which provides clients with read-write access to spatial data (Open Geospatial Consortium Inc., 2005).

This application can be used to enter management schemes for all parcels individually, from different owners. Management schemes define mainly when in the season a farmer starts to work on the land and what he does. Will the first grass be cut already in April or later? Will there be intensive grazing in April or will it be extensive grazing in May? The management scheme chosen determines the appearance of the crops (crop state) during the breeding season and accordingly, how this influences the success for the black-tailed godwit in raising their chicks. If available, data on the distribution of black-tailed godwit territories can be entered as well.

The available management schemes and crop states within the application are being managed by means of configuration files. These configuration files follow the Styled Layer Description specification. The OpenGIS® Styled Layer Descriptor (SLD) profile of the Web Map Service Implementation Specification defines an encoding that extends the Web Map Service specification to allow user-defined symbolization of feature and coverage data. It allows users to determine which features or layers are rendered with which colors or symbols (Open Geospatial Consortium Inc., 2007). The SLD's for the input application (figure 2) include the Code, Description and Symbol for management scheme or crop state.

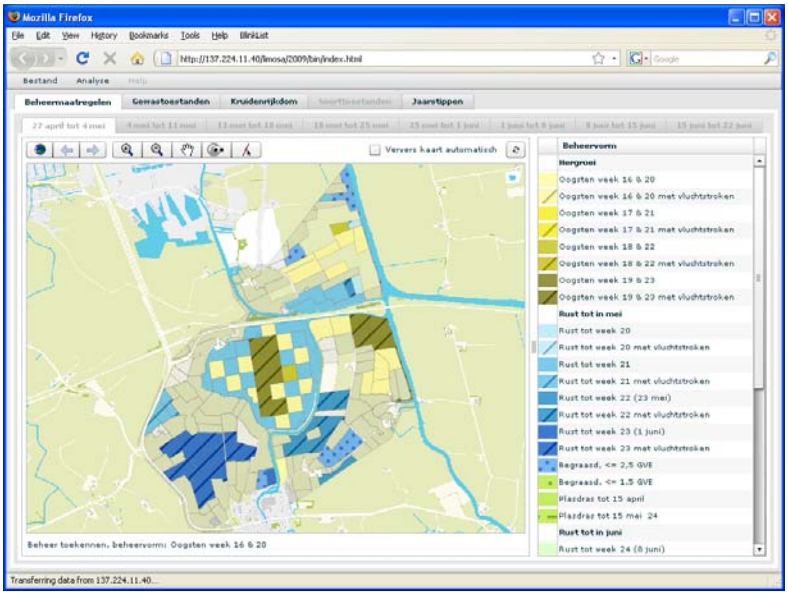

Figure 3. Internet GIS application for entering management schemes.

The management and territorial data collected using the internet GIS application are used as input for an ArcGIS computational model. Using this model, the quality of the management plan for the survival of the chicks is assessed. This information can be used to optimize the plan. Focus in this model (up till now confined to the black-tailed godwit) is to provide chicks with grassland vegetation which provides shelter and food at the right time and place. These qualities depend on management and landscape features. The model produces maps which show where and when there is a shortage or a surplus of such land. In case of a shortage or a surplus, agricultural nature conservation groups may decide to adjust their management schemes accordingly.

Since the black-tailed godwit breeding season lasts eight weeks, this analysis will be run eight times per year. For each week in the black-tailed godwit breeding season, the available amount of grassland suitable for raising chicks is divided over the number of black-tailed godwits present. The state of the grassland at the time of the scan is characterized by means of 18 appearances (crop states). The crop states determine de suitability of a parcel for the black-tailed godwit. This suitability is expressed as a factor which determines the weight of certain crop when determining the amount of actual available chick grassland (Nijland, 2008).

Each management regime can be described by a series of these crop states, apparent during the breeding season. Based on the management schemes, default crop states are assigned to the parcels. These crop states can be manually adjusted if needed, for instance when spring arrives later than anticipated, which the case is in 2009 in the Netherlands. Due to a much colder winter, spring is one and a half month later than the previous year 2008 (Anonymous, 2009).

As has been stated in the previous paragraph, the model calculates the amount of chick grassland for black-tailed godwit. It is too simple to presume that the available area can be divided by the number of birds.

The model needs the number of families which is actually present in a specific area as a parameter. A family is characterized by a nest or a territory. The number of territories which actually produce chicks differ in the season. It starts with a few territories, increases to a certain maximum and declines again. In the formula below this is presented as the fraction of territories with chicks.

The next parameter which is essential is the range of the chicks. Schekkerman et al. (1998) researched this topic and his figures are used in the model. If the chicks are young, they can cover smaller distances than when they are older. This influences the amount of surrounding area which is included in the calculations.

A third parameter is the chance of survival of the chicks. If many chicks die, this leads to more available chick-grassland for the remaining families or chicks.

With these parameters, the model can calculate the amount of suitable and reachable chick grassland. The simplified formula is:

> available chick grassland = (area chick grassland within range / number of territories with a claim on the available area) / fraction of territories with chicks

It has been made plausible that this formula is sufficient in case the black-tailed godwits are able to share the available chick grassland (Schekkerman et al., 1998, Schotman et al., 2008). But in case there are isolated birds that do not have chicks, it does mean that the available land can not be used by other birds because there aren't any. The formula should be adjusted to correct for this:

> available chick grassland = (area chick grassland within range / number of territories with a claim on the available area) / (fraction of territories with chicks + (1 – fraction of territories with chicks) / Number of territories which have to share chick grassland)

The following figures give an example? Based on the assumption that the amount of chick grassland is 6 ha, that 60 % of the breeding pairs have chicks and that there are 1, 5 or 10 black-tailed godwit families, the following amount of chick grassland is available:

- 1 family: (6/1) /(0.6 + 0.4/1) = 6,0 ha per family
- 5 families: (6/5)/(0.6 + 0.4/5 = 1.76 ha per family
- 10 families: (6/10) / (0.6 + 0.4/10) = 0.9375 ha per family

All output of the model is stored in an ArcGIS geodatabase. All relevant information is displayed in a single map. Apart from the model result displayed on a map, an overview with all relevant settings used in the model is presented.

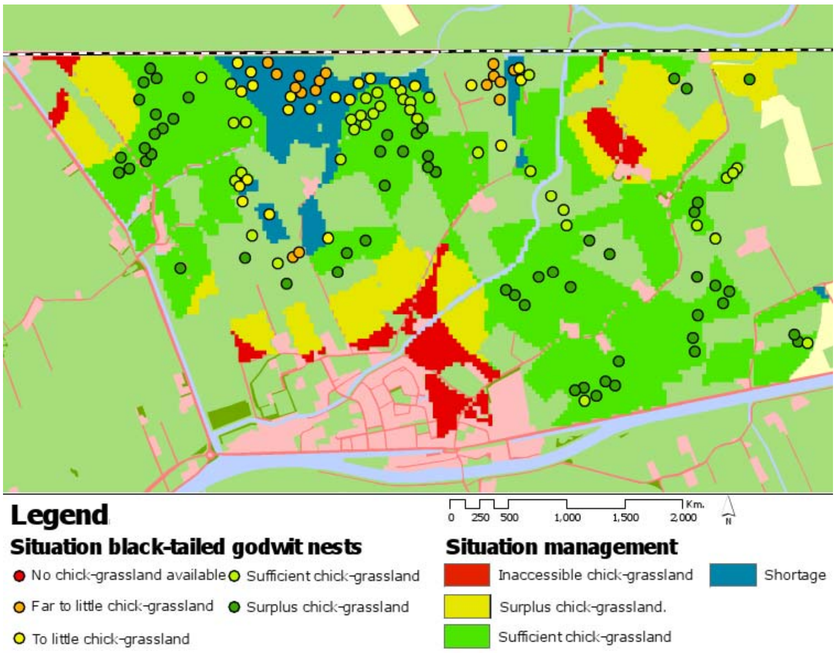

Figure 4. Example output of the model.

In 2008, the system has been used for 55 nature conservation groups (Melman et al., 2009, in prep.). For Alterra, the purpose was to test if the system works in daily practice and to obtain insights in the strengths and weaknesses. This insight can be used to further develop the system. The purpose of the agricultural nature conservation groups was to obtain an insight into the quality of the management scheme and if necessary to adjust it. This analysis was run before the black-tailed godwit breeding season. After the breeding season, the system was used to evaluate the management scheme again in order to compare planning and actual breeding results.

Error! Reference source not found. provides an example of the output of the model. The dots indicate black-tailed godwit territories.

3. RESULTS AND DISCUSSION

Testing has shown that the overall data entry takes approximately 3-4 hours per area. Most users were not experienced and worked with the system for the first time. It can be expected that more experienced users are able to enter a management scheme and territories of black-tailed godwits in two hours or less. It turned out that after users were introduced with the system, the entry of black-tailed godwit data was fairly simple.

Some assumptions in the model have proved to be to simple, while some parameters were just not part of the model. To increase the value of the outcomes, information on the state of the territories at the time the eggs hatches should be included. Also information on mortality rates of the chicks could be useful. It is not sure if this really improves the results in comparison with a more broader approach, but this should be investigated.

In the beginning of the project, the assumption was that godwits were very home-loving and that the territories were fairly fixed. Recent finding from De Molenaar et al. (2000) have proved that this is not the case at all. From a number of areas the distribution data has become available. It is now possible to further investigate the distribution dynamics and to find out if what the relation is with management of grasslands and, if needed, parameterize this relation in the model. Research from Roodbergen et al. (2008) made clear that there is a strong relation between breeding success and nest site fidelity.

In the end of 2008, there were a number of discussions on how to calculate chick grassland. These discussions were triggered by the test runs with nature conservation groups. Version management will be crucial to make it possible to compare and interpret the results between the years.

Even before the system was tested, it was anticipated that users would judge the system as being a tool which makes it possible for policymakers to control and monitor the behaviour or choices of the users, more than being a tool to assist the users. We were not disappointed in this, because this is exactly how people reacted. This was even more so in cases where local policymakers made it mandatory to use the tool in order to be eligible for subsidies.

Nevertheless, in general the tool received positive feedback from many agricultural nature conservation groups in the sense that the tool produced useful results.One nice remark was made by a user, a remark which may be related with a more often heard complaint that models do not reflect what really goes on.

> In the beginning we thought, here are those guys from Alterra again. We need to do some additional work again and we are already much occupied. But in the end, using this model opened our eyes. We thought that the model produced negative results, too negative even, because we had convinced many farmers to participate in a good quality management plan. But actual bird counts made clear that the actual situation was even more negative than predicted by the model. It became crystal clear that the situation was much less positive than we always thought it was.

Users of the system gave us a considerable amount of feedback, which enables the further development of the system. Some of the remarks were related to the model and the way the results were presented, other remarks were very specific on small details or on the other hand, very general.

To name a few of them:

- Possibility of data storage. The current version can only work for the current year. Management schemes from earlier years cannot be loaded into the system automatically, nor is it possible to store different concurrent management schemes for the same year. It should also be made possible to store black-tailed godwit distribution data for more consecutive seasons.
- Possibility to use the system for other species to test the effectiveness of specific management decisions for those species.

- Possibility for the users to load their own data with black-tailed godwit appearances into the system to avoid multiple data entry.
- More freedom to make evaluate adjustments during the season.

These remarks, amongst others, are valuable material to get more insight in how users work with the system, how they rate it and where it could be improved. It is certainly not sufficient to only deal with additional user-requirements on an ad-hoc basis. We need something more structured. Therefore we envisage that we should install a user-platform which will help us in defining priorities.

A model like the one described in this paper helps to bridge the gap between scientists and workers in the field on how an effective management scheme should be designed.

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