The role of the SQL date functions in a GIS for ecological conservation

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Summary

This paper demonstrates the use of temporally dynamic GIS attributes in devising and communicating ecological conservation constraints to construction projects. We embed SQL date functions into table view queries, using an open source database management system, to automatically calculate the ages of ecological observations in real time. In turn, the age attributes are then used in ecological analysis and monitoring applications, such as prioritising ecological survey efforts and estimating resilience to disturbance events. We conclude that the incorporation of temporally dynamic attributes in ecological datasets can help to reduce unnecessary development constraints, delays and expense.

KEYWORDS: temporal GIS; conservation; wildlife management; development; dynamic attributes

1. Introduction

European and UK laws expressly prohibit the anthropogenic disturbance of various animal species including bats, badgers, otters, great crested newts and a selection of birds (see Chartered Institute of Ecology and Environmental Management, 2014). This has a direct impact upon the construction industry, as measures must be taken to ensure that new development activities do not cause significant noise, vibrations or human presence in close proximity to the places that these animals occupy as shelters. New developments therefore often necessitate substantial conservation effort, involving the mapping of all protected animals inhabiting the site, continuous monitoring of how their distribution changes over time and the calculation of the spatial constraints these distributions place on construction activities (English Nature, 2002, Natural England, 2013, Scottish Natural Heritage, 2013a, b). As an example of the latter, works are not permitted within 30m of an otter holt (Chartered Institute of Ecology and Environmental Management, 2014), meaning that the locations of all otter holts must be found, mapped, and buffered accordingly.

In themselves, ecological practices of this manner can prove to be formidable tasks. The challenge however is intensified when developments have a multi-year duration, forcing ecologists to account not only for spatial constraints, but also their change through time due to temporal dynamics in species populations, migrations and habitat usage. Whilst guidance offered by ecological conservation bodies, such as Natural England and Scottish Natural Heritage, and the British Biodiversity Standard (British Standards Institute, 2013) detail the survey methodologies and buffer distances required for such a conservation style, they fail to address many of these associated temporal complexities. For example, Wood et al. (submitted-a) found that no guidance is given regarding the length of time an otter's resting place must remain unused before its protection can be dropped. If protection is enforced unnecessarily, then the financial cost associated with the redesign of the site and/or ecological mitigation (such as creating an artificial resting place) is equally unnecessary. Similarly, dropping the protection prematurely would facilitate the removal of a resting place which may have

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been used in the future.

Although GIS solutions have long proved to be a popular choice for ecologists to capture, record and present ecological data relating to development works, and to calculate associated buffer distances, 'out of the box' GIS software fails to adequately represent these temporally dynamic data. This difficulty is exacerbated by the fact that the skill set of many practicing ecologists and decision makers (in both the spheres of regulation and development planning) encompass only basic GIS techniques (Wood et al., submitted-b).

This paper presents initial research into a GIS architecture which enables the automatic calculation of temporally dynamic attributes, and illustrates its application to protected species conservation. We aim to address a number of issues identified during previous work (Wood et al., submitted-b). First, we discuss a system architecture to facilitate a centrally stored pool of ecological data, which can be accessed by a variety of users, each using different software and possessing different GIS capabilities. Second, we outline a methodology to automate the processing of spatio-temporal dynamics to increase usability among novice users. Third, simple examples are illustrated using a case study site located in Scotland. Finally, explore the potential for more complex spatio-temporal modelling such as accounting for seasonal variations in resilience to anthropogenic disturbance such as that documented by Ruddock and Whitfield (2007).

2. Methodology

PostgreSQL with the PostGIS spatial extension served as the database management system (DBMS) platform for the solution. Tables were created for each set of protected features exhibited on the development site, including badger sett entrances, otter holts and rests, bat roosts and nests for various species of bird. Geoserver was then utilised to generate web feature services (WFS) and GeoJSON data structures to feed into various client GIS interfaces including ArcGIS, QGIS, uDig and will later feed an android application currently in development (Figure 1). By relying on interfaces that were familiar to the user, the learning curve in data exploration and utilisation was significantly reduced when compared to implementing a custom browser based interface for example. Feeding ecological data to clients in this manner also meant that it could be used to spatially query other spatial data held on the client, a feature deemed important by potential stakeholders as part of earlier research (Wood et al., submitted).

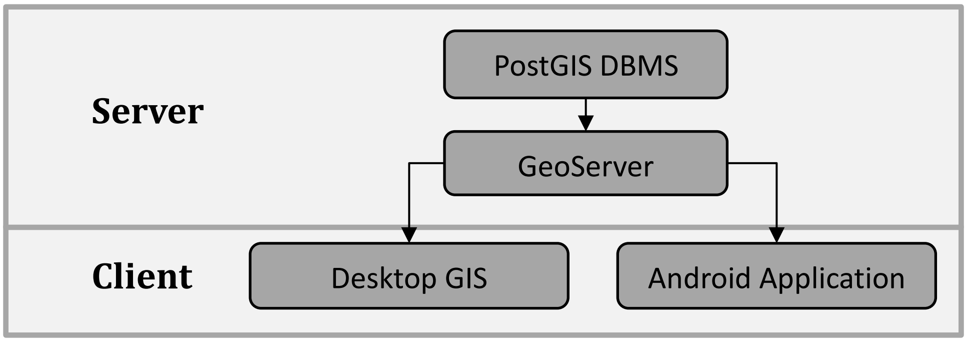

Figure 1 **System architecture**

Each record in a PostGIS table represents an individual protected ecological feature, each with three date fields: start_date, last_observed_date and end_date. An additional activity attribute was added allowing ecologists to fill in 'High' 'Medium' 'Low' and 'Zero'. When a field ecologist observes the feature, as part of ongoing monitoring efforts, they take one of two courses of action. If no changes in activity are noticed, the ecologist simply updates the last_observed_date attribute. If a change is noticed, then the current date is entered into the end_date attribute and a new record is made for the feature containing the current date in start_date and last observed date attributes (see Tables 1a, b and c). Views were then created in PostGIS to dynamically populate time dependent attributes each time an update is requested from the client.

Name	start_date	last_observed_date	end_date	Activity
Sett 1	01/01/2014	01/01/2014	NULL	High

Table 1a **Example record of a badger sett observation**

Name	start_date	last_observed_date	end_date	Activity
Sett 1	01/01/2014	01/02/2014	NULL	High

Table 2b **Example update to Table 1a where activity remains the same**

Name	start_date	last_observed_date	end_date	Activity
Sett 1	01/01/2014	01/01/2014	01/02/2014	High
Sett 1	01/02/2014	01/02/2014	NULL	Low

Table 3c **Example update to Table 1a where activity has changed**

3. Implementations and discussion

In the simplest form of date dependent attributes illustrated here, an age attribute was created using the function age(last_observed_date). This gives the number of days since the ecologist working on the case study site last observed the feature, which proved extremely useful in planning daily work schedules. This attribute was also of interest to the environmental regulator, who ensures that all development works comply with national and international laws. The addition of an age attribute allowed the regulators to see that ecological monitoring activities, prescribed as part of the planning conditions, were being adhered to.

Since start_date is never altered, running the function age(start_date) on the most recent instance of the feature, yielded the length of time activity remained constant for. For otter holts for example, where 'zero' activity was consecutively recorded for over one year, the status of the feature could be dropped from 'active' to 'inactive', allowing decision makers to apply less weight to these records in further spatial analysis. After two years of no activity the feature status could be dropped further to 'historic' where protection zones derived under CIEEM (2014), Natural England (2013) and Scottish Natural Heritage (2013a, b) guidelines, were removed altogether (Figure 2). The timespans were agreed through face to face discussion between ecological experts and regulators undertaken throughout the summer of 2014. When compared to more traditional approaches to ecological constraints mapping (see British Standards Institute, 2013), which typically use a single temporal snapshot to represent data for the entire time span of the project, this new methodology facilitated notable improvement. By removing unnecessary ecological constraints, developers are saved both time and money that would have either been spent on lengthy licence applications to disturb the feature or to undertake alternative work procedures. Equally, if the methodology becomes more widely adopted, the number of unnecessary licence applications submitted to regulatory authorities would be cut and would free up their time to pay closer attention to those applications that warrant it.

Figure 2 Demonstrating the use of temporally dynamic attributes to categorise the otter holts. The top map shows results from the initial otter survey in 2011 and the bottom shows the results of the spatiotemporal modelling in 2014 outlined in the main text

4. Conclusion and future research

This paper presented two simple examples where use of the age() function (part of many DBMS' including Postgres) coupled with a table view, have added significantly richer information to ecological GIS data. Though the age() function is relatively easy to use in this manner, its use in creating dynamic attributes is seldom implemented.

The next step in our research is to model spatio-temporal variation in disturbance susceptibility. This will consist of a lookup table with different buffer distances for different times of year and for different ages of the feature. Different types of badger sett experience different usage frequencies on a seasonal basis for example (Roper et al., 2001), and could be reflected with larger buffer distances in periods of heightened activity. Additionally, Ferguson-Lees et al. (2011) note that different bird species vary in time taken to build nests, egg incubation periods and juvenile rearing, each of which can be associated with different susceptibilities to disturbance. An android application will then be developed to use these spatio-temporally variable buffers as geofences (see Namiot and Sneps-

Sneppe, 2013) to alert site engineers if they accidentally move into a protective buffer zone. Ultimately, it is hoped that the examples of temporally dynamic attributes presented here, will serve in creating more robust ecological constraints mapping. Additionally, it is hoped that our use of the age() function and table views, will spark ideas for its application in other areas of research.

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6. Biographies

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Carly Stevens is a Lecturer in ecology at Lancaster University whose main research interests are related to the impacts of global change on plants and soils.

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