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LEVERAGING SURFICIAL MAPPING TECHNOLOGY FOR SUSTAINABLE COASTAL DEVELOPMENT

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INTRODUCTION

At the onset of a development resurgence, the central Oregon Coast counties are positioned at a pivotal time for creating sustainable growth opportunities. The central Oregon coastal plain is primarily comprised of active or stabilized sand dunes that extend 0.5-3 miles inland and range in age from present to 111,000 years old. These paleodunes contain various layers of interbedded soils, sand, iron oxides and deflation zones that complicate engineering and hydrologic site assessments. To analyze land use opportunities and risks for Lincoln County in the central Oregon Coast, an integrated Geographic Information System (GIS) data set is created. This data set utilizes new surface mapping of coastal plain deposits with other topographic and hydrologic coverages. To illustrate the importance of the paleodune deposits on the sustainable development of the Oregon Coast we are producing detailed surficial geology maps using a GIS dataset of the paleodunes' distribution, emplacement age, relative cementation, shallow stratigraphy, and associated geotechnical properties. These maps also incorporate other GIS coverages including jurisdictional boundaries, infrastructures, digital elevation models, surface hydrology, cadastral and known cultural sites. The overlapping coverages demonstrate the unique geospatial relationships between the coastal plain surface deposits and associated foundation soils, groundwater contaminant flow paths, and sensitive upland habitats in the paleodune landscape. The geospatial relationships are the first application of recent surficial mapping within a complete coastal dune system on the Oregon Coast.

BACKGROUND

The Lincoln and Newport dune sheets are located on the central Oregon Coast (Figure 1). The geomorphic features of the area's coastal plain began forming in the Pliocene and later through the Pleistocene and Holocene. Approximately one million years ago continental glaciation caused global sea level fluctuations (Orr, 1992); these fluctuations caused rapid erosion of the Tertiary deposits of sandstones and siltstones along the Oregon Coast (Reckendorf, 1998). During the eustatic high stands of sea level Pleistocene wave-cut platforms were formed. The sea level fluctuated during the Pleistocene, thereby creating multiple wave-cut platforms. These platforms were then tectonically uplifted producing stacks of several coastal terrace levels along the Oregon coast (Cooper, 1958).

With the lowered sea levels on the inner shelf during Pleistocene glacial periods, the exposed inner-continental shelf was exposed to the subaerial environment (Peterson et al., 2002). During low-stand periods of the late Pleistocene the dune sheets were fed by across-shelf sand supply from low-stand shoreline deposits (Peterson et al., 2002, Peterson et al., 2006). The Pleistocene dunes were able to accrete and migrate inland during periods of enhanced across-shelf sand supply, onshore wind forcing, and diminished vegetative stabilization. The area experienced a marine transgression during the Holocene, which lead to the formation of thin dune caps on top of the sea cliffs (Reckendorf, 1996).

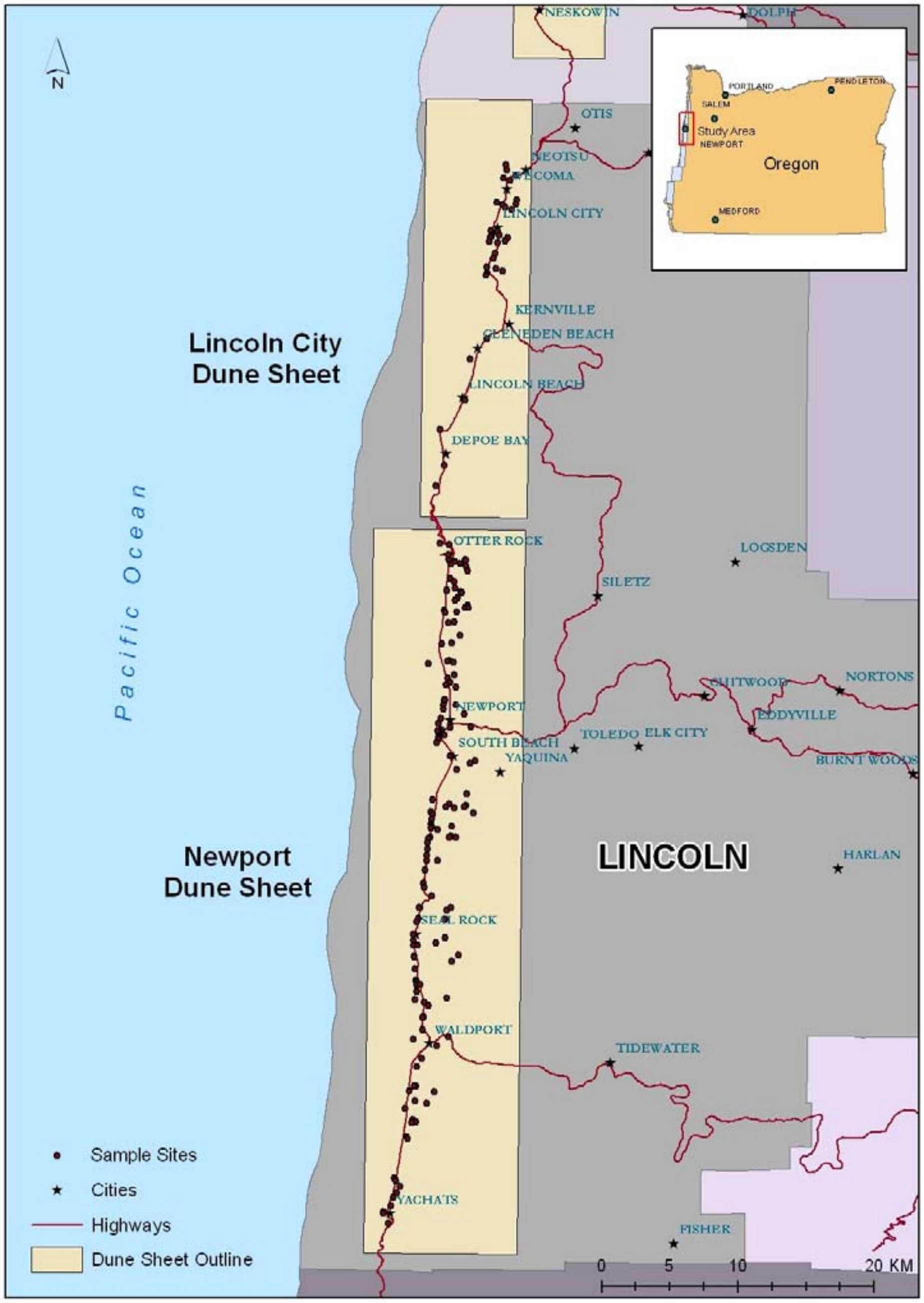

Figure 1-Map illustrating the location of the dune sheets and the sample sites in this study.

The paleodunes deposits are largely limited to the low-stand Pleistocene dunes in the central Oregon coastal area. The Pleistocene dune sheets decrease in landward width from 3 km in the Newport dune sheet to about 1 km in width in the Lincoln dune sheet.

The dune sheets mantle the preserved marine terraces, where approximately 90% of all residential, commercial and public development occurs in the central coastal areas (Clough, 2005). The origin of these paleodune deposits have been extensively studied by Cooper, 1958; Reckendorf, 1998; Peterson et al., 2006, however the paleodunes and underlying deposits have not been distinguished in published geologic maps. It is important to map the thickness and extent of the paleodune deposits because of their unique geotechnical and hydrological properties. Development problems such as slope failure, drainage, coseismic liquefaction, settlement and erosion are persistent in the central Oregon coastal plain. Paleosol aquitards in the Pleistocene dunes lead to perched water tables, and locally problematic drainage. E. coli contaminations of public beaches in Lincoln City are linked to septic and sewer system drainage into the Pleistocene dune aquifer, which discharges along the public beaches (Peterson et al., DEQ Report, unpublished, 2003).

Previous studies and maps of the paleodune sheets do not differentiate between the Pleistocene beach deposits and stratified dune deposits; soil survey maps only address the upper 1.5 m of the parent deposits (Clough, 2005). Considering these limitations of existing soil and geologic maps it is important to develop comprehensive surficial maps of the dunesheet deposits. The availability of such maps will enable land use interests to make informed decisions regarding foundation soils, cut slope stabilities and subsurface drainage.

METHODS

To gain insight as to what will make the GIS dataset useful for Lincoln County and Newport City officials, geotechnical consultants, and other land use interests, potential users of the dataset were surveyed about format, scale, and attribute preferences. The survey was an anonymous questionnaire of closed, multiple choice questions distributed to participants either by mail or in person (Robson, 1983). The sampling method used for the survey was a combination of purposive and snowballing. Purposive sampling was used to specifically target participants that influence or directly impact land use decisions. Snowballing sampling was also utilized, asking respondents to refer other potential participants to increase the sample size (Robson, 1983).

The survey was distributed in November of 2006, after analyzing the survey results we designed a MS Access database. The paleodune field data, which was collected from 1997 to 2000 through an Oregon Sea Grant Project, was then imported into the Access database and then used to create an ESRI ArcMap geodatabase. Providing both formats will allow future users the ability to manipulate the data with ease in order to fit their specific needs.

The Dune Sheet GIS dataset is used in conjunction with roads, digital elevation models (DEMs), surface hydrology, cadastral and jurisdictional data to create surficial maps of the area. With DEMs we are able to identify areas with potential groundwater leaching of dune cements as well as cut-slope failures based on the angle of the slope; similar methods are applied to compare Pleistocene paleosols, low slopes and perched water tables to identify possible drainage issues for septic systems and overland flow. Groundwater flow paths are established from the slope gradient to determine areas at risk for contamination from septic systems and leaking sewer systems. The slope data coupled with surface hydrology and dune sheet profiles show sensitive wetland habitats that are at risk for contamination as well as lowered groundwater level from adjacent, constructed drainage systems.

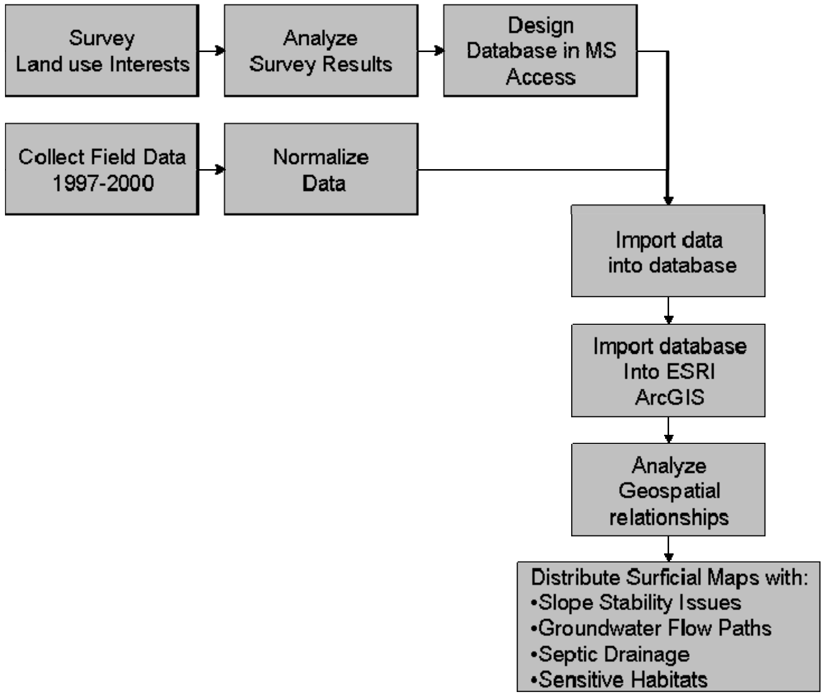

Figure 2-Flow Chart showing the data process for creating the paleodune surficial maps.

RESULTS & DISCUSSION

The use of social surveys in scientific, specifically geologic projects is unusual, however it may prove to be a good tool to illustrate to public and private land use interests the significant impact of geologic processes to sustainable development in the coastal plain. The survey is an important aspect of this project because it engages the end user in the development process of the data set. Because of their involvement early in the project we anticipate the users to feel more comfortable and have a greater willingness to employ the surficial maps into coastal plain planning efforts. The table below includes survey results from three of the six topics covered in the questionnaire. The participants rated their interest level in each subject as Least, Moderately, or Most. The percent below is the normalized value for responses that fall in the Most interested category. The three topics not included in the table are preferred GIS format, base map scale, and data delivery method.

Attributes	Normalized %	Risks	Normalized %	Coverage Area	Normalized %
Geological	30	Unstable Slopes	46	Region	9
Topographical	24	Liquefaction	23	County	51
Geotechnical	16	Drainage	15	City	40
Hydrological	20	Contaminant Flow Path	7	Drainage Basin	0
Environmental	0	Drainage Basin	9		
Jurisdictional	5	Habitat Impacts	0		
Infrastructure	5				

Table 1-Normalized survey results for three of the six topics covered on the questionnaire.

The lack of geological expertise makes it difficult for planners and engineers to interpret morphostratigraphic logs from field studies of the dunesheets. The surficial GIS models created from this project integrate geologic analysis of the paleodunes with existing thematic data. The geospatial relationships of this data will enable the user to better understand the unique geologic issues of the coastal plain. Including the data in both MS Access and ArcMap formats provide flexibility, allowing users to update the dataset quickly and to incorporate new layers as they become available (Longhorn, 2003). This integrated approach should make geotechnical and hydrologic data more accessible to policy makers improving sustainable development efforts in the coastal plain.

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