WATERSHED CHARACTERIZATION FOR PLANNING BETTER AGRICULTURAL PRACTICES AND ENVIRONMENTAL MANAGEMENT*

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RESUMO: Este trabalho tem como objetivo caracterizar uma bacia hidrográfica e identificar as áreas de preservação permanentes e nascentes para aplicar melhores práticas de conservação na região e reduzir a poluição de insumos agrícolas nas águas subterrâneas e superficiais. O sistema de informações geográficas ArcGIS, o modelo ArcSWAT e técnicas de fotointerpretação da rede de drenagem foram utilizados para delinear a bacia e identificar das áreas. A zona de conservação de 30 m resultou em áreas de 2671, 2871 e 3063 ha, para os métodos de interpretação ArcGIS, ArcSWAT e fotografia, respectivamente. Recomenda-se fazer a entrada de saída de dados manualmente das redes de drenagem e pontos de nascente.
PALAVRAS CHAVE: sistema de informação geográfica, recurso hídrico e bacia hidrográfica.

ABSTRACT: The overall project goal was to identify headwater streams in the Córrego Rico watershed, so that areas could be selected for implementing agricultural conservation practices that minimize impacts of production on groundwater and superficial water. This project's objective was to compare stream systems created using a Geographic Information System (GIS) tool (ESRI ArcGIS®), a watershed modeling tool (ArcSWAT), and manual photo interpretation of the watershed. Buffering each stream system with the regulatory 30 m conservation zone resulted in total areas of 2671, 2871, and 3063 ha, for the ArcGIS, ArcSWAT, and photo interpretation methods, respectively. Thus, use of GIS tools should be used only when results are verified to prevent incorrect implementation of regulatory protection measures.
KEYWORDS: geographic information system, hydro resources, basins.

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INTRODUCTION

The availability of Geographic Information Systems (GIS) software (e.g., ESRI ArcGIS®) and corresponding GIS data provides a relatively new tool for evaluating surface-water flows and groundwater levels. The connectivity of surface water and groundwater suggests that the watershed is a logical spatial unit for such analyses [1]. Use of GIS technology for understanding watershed systems has provided environmental managers with additional methods for targeting limited resources and identifying potential problem areas [2]. Differences among methodologies need to be quantified as results from such analyses may be used for regulatory enforcement and/or water resource assessment. For the Córrego Rico watershed, protection of its surface water and groundwater resources has been shown to be dependent on implementation of buffer zones around the stream system – particularly in the headwater streams [3]. Thus, our project objective was to compare stream systems created using a Geographic Information System (GIS) tool (ESRI ArcGIS®), a watershed modeling tool (ArcSWAT), and manual photo interpretation of the watershed to assess the applicability of such tools in this watershed.

METHODOLOGY

The Córrego Rico watershed, which encompasses 542 km^2, is located in the northeast portion of São Paulo State, Brazil and is designated at the 9^{th} unit of the Water Resource Management Units (UGRHIs) of the State Water Resource Management System and State Water Policy. The Digital Elevation Model (DEM) for the watershed was conceded by EMBRAPA, produced by NASA, NIMA (*National Imagery and Mapping Agency*), DOD (*United States' Department of Defense*) and Germany and Italy Spatial Agencies, after refined by Embrapa Relevo Project [3] in the South American Datum 1969 (SAD 69) UTM Zone 22S projection, 90 m resolution, and grid position of 756.46 km to 794.63 km east, 7628.14 km to 7652.34 km north. The original DEM SRTM was interpolated to 20 meters of spatial resolution using a *spline* filter and the projection coordinate system was converted to Córrego Alegre (the same projection used in the shape of drainage network edited manually). ESRI ArcGIS 9® was used to identify the stream system using the Hydrology toolset. This toolset creates a stream system based on the DEM supplied by the user: basin

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(creates a raster delineating drainage basins), fill (removes small imperfections in the data), flow accumulation (creates a raster of accumulated flow into each cell), flow direction (creates a raster of flow direction from each cell to its steepest downslope neighbor), and watershed (determines contributing area above a set of cells) (ESRI, 2010). The watershed modeling tool selected for identifying the stream network was the Soil and Water Assessment (SWAT) model [4]. SWAT (more specifically ArcSWAT, which is the ArcGIS® interface version of SWAT) identifies streams using a DEM and the ArcMap Spatial Analyst® extension. For this application, a 50 ha threshold value was used without modification of outlets or stream burning (Di Luzio, 2002). The photo interpretation was completed using digital images from the aerial survey of the watershed in 2000 by *BASE Aerofotogrametria e Projetos S.A.* In each photo of the stereo pair, the drainage net was interpreted using a stereoscope, and they have the ground control points. The stream network was vetorized in AutoCad 2008® to create the shape file of the manual photo interpretation. Buffers were estimated for each of the three stream networks to compare protected area using the different methods using ArcGIS®.

RESULTS AND DISCUSSION

Differences observed were due to the procedures used for each method. Considering the 30 m regulatory buffer region for each stream network, the protected area for the ArcGIS®, ArcSWAT, and manual photo interpretation methods were 2671, 2871, and 3063 ha, respectively. Results show that the ArcGIS® and ArcSWAT stream delineations identified fewer headwater streams (Fig. 1). These results suggest that the stream delineation method does influence the total protected area and thus likely influence water quality protection goals. Identification of stream networks should be done considering the limitations of each methodology, particularly those that use computer analyses which may not accurately depict smaller, headwater streams, (It's not an absolute conclusion because the resolution and precision of the model (DEM) can change the final results. So, how much better is the model, more refined will be the final result). We need to take account that the original resolution of the SRTM DEM is 90m). The results would be better than this if the original resolution of the DEM were more refined.

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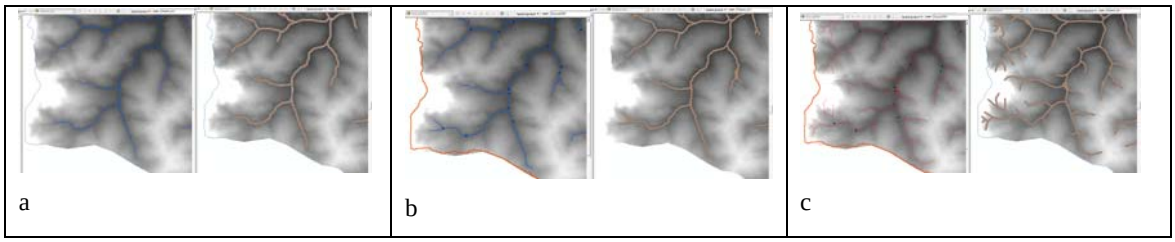

Figure 1. The drainage network and buffers generated by ArcGIS (a), ArcSWAT (b) and manually (c).

CONCLUSION

This project's objective was to compare stream systems created using ArcGIS, ArcSWAT, and manual photo interpretation of the watershed. Results showed that each method produced different stream delineation for the watershed. Considering a 30-m buffer around each stream network, which is a current Federal regulation in the watershed, this would correspond to 2671, 2971, and 3063 ha for the ArcGIS, ArcSWAT, and photo interpretation methods, respectively for agricultural conservation practices that minimize impacts of production on groundwater and superficial water.

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