English Version

SIG applied in the analysis of the conflict of soil use in permanent preservation areas in a watershed

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Abstract

The work sought to obtain the conflict of land use in areas of permanent preservation in the Ribeirão Descalvado watershed - Botucatu (SP), having as cartographic bases: the planialtimetric map (IBGE, 1969) used in the georeferencing and the satellite image of 2005. The SIG-IDRISI was used for conversion of the analogical information for digital and determination of the areas. The land use showed that the pastures occupy most of the area (68.18%) when analyzed the figures of 2005. The pastures are more than half of the area showing with that the predominance of soils of low fertility, besides the prevalence of the livestock in the area. The satellite image allowed the mapping of the soil use in a reliable way, and will be used for futures regional planning. The area is being environmentally preserved, since it is covered with almost 20% of forests (19.32%), minimum demanded by the Brazilian Forest Code effective (20%). The Kappa index obtained was 0.41, had as good according to the classification. The delimitation of the drainage net was made for the obtaining of the areas of PPAs and of conflict, which showed that only 60.93% are being busy appropriately for ripparian forest.

Key words: watershed; remote sensing; SIG-IDRISI; preserved area

Introduction

The analysis of land use and cover, through information of Remote Sensing, is a technique of great utility to plan and manage the ordered and rational occupation of the physical environment, besides it enables to evaluate and monitor the preservation of areas with natural vegetation. Using the interpretation of satellite images it is obtained, in a fast way, an updated and accurate thematic map of the different spatial structures resultant of the process of land occupation and use (RODRÍGUEZ, 2000).

The remote sensing data has great application in the quantitative description of the watershed and drainage networks. Thus, a series of morphometric studies, formerly performed based on data extracted from topographic maps, started to be done based on remote sensing data, i.e., using images collected by remote sensing (NOVO, 1992). The extension of the Brazilian territory and the little knowledge of the natural resources, allied to the cost to obtain information trough conventional methods were the decisive factors for the country to enter in the satellite remote sensing program (ROSA, 1995).

SIGs are, according to CALIJURI and ROHN (1994), an excellent tool to investigate several phenomena, related to the urban engineering, environment, pedology, vegetation and watersheds. This way, computer came to solve a large part of the problems with time, workforce and the small accuracy when the volume of information is large (PEREIRA et al., 1995).

The option of a watershed as study place is due to the fact that this is a unit with different features, from high regions, where normally are located the sources of the streams and creeks, slope areas where water flows with more speed, and, finally, the lowland areas where normally the consequences of the inappropriate management done in the highest areas are observed.

One of the advantages of using the remote

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sensing for the interpretation of the land use is that the information can be updated due to the characteristic of repeatability of image acquisition.

In this sense, according to ROSA (2003), the systems of remote sensing available today allow the acquisition of data in a global, reliable, fast and repetitive way, being data of great importance for the surveying, mapping and use of the information of land use and occupation of a certain region.

The monitoring of the dynamics of the land use in the municipalities has a great importance in the aim to reflect over the changes of socio-economical aspects of certain regions and even to allow their environmental monitoring.

The inappropriate use of soil by man is an aggravating factor in the environmental degradation and ecological unbalance. It is necessary that the acting of man in the environment is planned and appropriate so that the effects to the physical environment are minimized (MOTA, 1981).

In this context, the satellite images are an important tool, well established, as a source of data about time and distance enabling analysis of the chance which occurred in the land use, i.e., in the way that space is being used by man.

The present work had as objective to evaluate the use of geotechnologies in the mapping of the land use and cover, areas of permanent preservation – APPs and of conflict between land use and APPs, and, for future contribution in the process of environmental management and in the decision taking by the Public Managers.

Material and methods

The Ribeirão Descalvado watershed is located in the North region of the municipality of Botucatu (SP). Its geographic situation is defined by the coordinates: latitude 22º 50' 05" to 22º 54' 26" S and longitude 48º 26' 36" to 48º 22' 29" W Gr, with an area of 2051.13 ha.

The predominant climate of the municipality, classified according to the Köppen system, is Cwa – Humid subtropical climate with dry winter and hot summer – in which the temperature of the coldest month is inferior to 18 °C and the hottest month is superior to 22 °C.

The control points (coordinates) for the georeferencing and delimitation of the borders of the watershed were based on the Planialtimetric Map, edited by the Brazilian Institute of Geography and Statistics – IBGE in 1969, page of Botucatu (SF-22-R-IV-3), scale 1:50000.

The areas with vegetal covers were obtained by panchromatic aerial photography coming from the aerialphotogrametric coverage of the state of São Paulo, from 1962, with approximate nominal scale of 1:25000 and by colorful aerial photography coming from the aerialphotogrametric coverage of the state of São Paulo, from 2005, with approximate nominal scale of 1:30000, with longitudinal recover of approximately 60% and 30% in the lateral, as well as by digital satellite image, bands 3, 4 and 5 of the "Thematic Mapper" sensor of LANDSAT – 5, orbit 220, point 76, quadrant A, passage from 2005, scale 1:50000.

The conversion of the vetorial data in raster image and their processing were performed with aid of the Geographic Information System – Idrisi, version Andes, as well as the determination of the land use of the Ribeirão Descalvado watershed.

The delineation of a watershed is given by the dividing water lines that demarcate its border. These lines are defined by the conformation of the level curves existent in the planiatimetric maps and connect the highest points of the region around the drainage (ARGENTO and CRUZ, 1996).

The contour of the area of the Ribeirão Descalvado watershed – Botucatu (SP) was performed manually in the Planialtimetric Map edited by the Brazilian Institute of Geography and Statistics – IBGE in 1969, page of Botucatu (SF-22-R-IV-3), scale 1:50000, following the highest points around the drainage, having as a base the definition given by ROCHA (1991) of watershed.

Later, it was scanned and imported to the Geographic Information System – IDRISE Andes in the format .BMP, generated in the process of scanning, to the format .IMG by the module File/ Import.

Following it was made the georeferencing, using two files of control points, the first one of the digital image and the other one, of the topographic map of Botucatu (SF-22-R-IV-3), edited in 1969

by IBGE. The coordinated of each point were determined, and with this data it was made a correspondence file, through the command "Edit" of the menu "Database Query", present on the module "Analysis". After the georeferencing, the digitalization of the limit was performed trough the computer screen using the module "digitalize".

The stereoscopic observation of the pairs of panchromatic aerial photography was performed with aid of the mirror stereoscope of the trend Wild, model ST-4 and the transference of the elements of interest to the photos to the base map was performed with aid of the Aerosketchmaster Carl Zeiss, Yena.

In order to obtain the map of the vegetal cover from 1962 and 2005 it was done, initially, a photomontage with all the set of panchromatic aerial photography correspondent to the area of the Ribeirão Descalvado watershed, being next drawn the flight lines and the limits of the effective area, according to COELHO (1972); after that, with aid of stereoscopy it was modeled, in polyester film Terkron D-50 microns, the areas of the vegetal covers, object of study.

The maps of the vegetal cover from 1962 and 2005 were scanned for transformation to the digital form. Then, the vector file was imported to IDRISI in the format TIFF, to be georeferenced and scanned the areas of the vegetal covers, being, later, indicated the names of each cover area, associated to its following identifiers. The areas and percentages of each vegetal cover were determined trough the command "Area" of the menu "Database Query", which belong to the module "Analysis".

Then, it was elaborated a composition false color with the combination of the bands 3, 4 and 5, obtained from the image of digital satellite, bands 3, 4 and 5 from the sensor "Thematic Mapper" from LANDSAT – 5, orbit 220, point 76, quadrant A, passage from 2005, scale 1:50000, since this present a good visual discrimination of the target, enabling the identification of the patterns of land use in a logical way. This composition presents water bodies in tones of blue, the forests and other forms of vegetation in tons of green and the exposed soils in tones of red. Later, it was made the georeferencing of the false color composition, using for this the module Reformat/Resample of the GIS – IDRISI, in which the control points were obtained in the planialtimetric maps of IBGE (1969), scale 1:50000, municipality of Botucatu (SF-22-R-IV-3). After the georeferencing, it was made the cut, extracting only the watershed area. Posteriorly, the training areas were marked over the image with the cursor and the mouse. These areas were marked over a great number of places, aiming to cover all the variations of each land occupation.

Later, signatures were created by the module Makesign and the classification supervised by the method Maximum Likehood, through the module Maxlike. In the supervised classification, the soil occupations were identified and differenced by their pattern of spectral response, in which the training areas were limited by polygons drawn over each land use in the image. Then, the names for each class of land use were indicated, associated to their respective identifiers. The image was classified and the demonstrative cartograms of the spatial distribution of each land use based in this data.

In the digital identification of the targets, it was used the image interpretation keys (ROCHA, 1986) for the determination of the classes of use.

After the elaboration of the map of land use, the areas were determined with aid of the software GIS – IDRISI, using the command "Area" of the menu "Database Query", which belong to the module "Analysis", being later determined the percentages of each class.

The accuracy of the mapping was obtained statistically through the use of Kappa index. This procedure suggested by EASTMAN (1999) and by SIMÕES (2001), was initially constituted in the generation of points of sampling randomly stratified, through the module Sample. The land occupation (satellite image from 2005) in the pixel referent to each point was identified, being created later a file of values related to the sampled points of the land truth (aerial photography). These two files were associated and after that were rasterized, generating a raster image with the land truth. Later, in the module Errmat it was statistically analyzed the supervised classification confronting the image containing the land truth with the classified image of land use. As result of this confrontation, it was generated an error matrix and the general and category Kappa index

(LANDIS e KOCH, 1977).

The areas of permanent preservation were defined along with the water courses of the Ribeirão Descalvado, using the operation Buffer Selected Features of the software ArcView 3.2, which provided the creation of a buffer of 50 m of radius in the areas of the sources and a buffer of 30 m of each size of the drainage over the streams, with this resulting in a map of APPs founded on the resolution CONAMA n° 303/2002, Art. 3°: "constitui Área de Preservação Permanente a área situada em faixa marginal, medida a partir do nível mais alto, em projeção horizontal, com largura mínima de trinta metros, para o curso d'água com menos de 10 metros de largura"[1], and in the Forest Code (Law 4.771/1965), which consider these areas, covered or not by native vegetation: "com a função ambiental de preservar os recursos hídricos, a paisagem, a estabilidade geológica, a biodiversidade, o fluxo gênico da fauna e flora, proteger o solo e assegurar o bem-estar das populações humanas".[2]

Using map algebra (map of land use x APPs) it was performed an overlap or "overlay" of the map of land use and cover with the map of the APPs to identify the areas of conflict of use at the APPs. The procedures were executed in the tool Raster Calculator in the module Spatial Analyst do ArcGIS

This procedure enabled the delimitation of the areas of land use, qualifying and quantifying the areas which were contained in the limits of the APPs, according to the methodological procedure (Figure 1).

Results and discussion

The vegetal cover suffered and has been suffering constant changes over the years with the action of the human being. This dynamics is more intense in soils with better fertility and with ecological conditions more conductive to agricultural exploitation.

The survey of the land use in a certain region becomes an aspect of main interest to the comprehension of the patterns of space organization. Thus, there is a necessity of constant update of the registers of land use, so that their trends may be analyzed.

The knowledge of the environmental alterations caused by human action enables a vision of the existing problems and gives support to the management of the natural resources. It is a main condition to program a policy of rational use of soil and respect the susceptibility and capacity of the environment to tolerate the human impacts, enabling the sustainable socio-economical development.

The analysis of the aerial photography from 1962 and of the digital image referent to the passage from 2005 in color composition bands TM3 TM4 and TM5 from Landsat 5 trought the Geographic Information System (GIS) – IDRISI allowed to discriminate, map and quantify four features trough the supervised classification in the watershed studied: reforestation, forest, pasture and others (Figures 2 and 3 and Table 1).

The analysis of land use of the Ribeirão Descalvado – Botucatu (SP) watershed shows that the pastures are the vegetal covers which occupy most part of the area, representing more than 68% (68.18%), i.e., cover 1398.58 ha, showing with this the predominance of soils with low fertility and predominance of regional agriculture (CAMPOS, 1993).

Among the covers that had their areas reduced in the period, forests decreased in 41.71%, i.e., went from 949.42 ha (46.29%), in 1962, to 395.99 ha (19.32%), in 2005. This percentage that still remained generally is located in relief with steeper topography, where the conditions to the mechanization and access are practically impossible (CAMPOS et al., 1998), besides being less favorable to the agricultural activity.

The areas of reforestation decreased in the period in function of the increase of the pastures. Cardoso proved in 1988 that the soil cover by reforestation was efficient in the protection of the drainage net in regions with erosive processes. In this sense, COELHO (1968) already affirmed that since the clear of natural forests are not prevented and their regeneration is slow, the culture of eucalyptus

1 Constitutes an Area of Permanent Preservation the area located in marginal strip, measured by the highest level, in horizontal projection, with minimum width of thirty meters, for the course of water with less than 10 meters of width.

2 With the environmental function of preserving the water resources, the landscape, the geological stability, the biodiversity, the gene flow of the fauna and flora, of protecting the soil and assuring the welfare of human population.

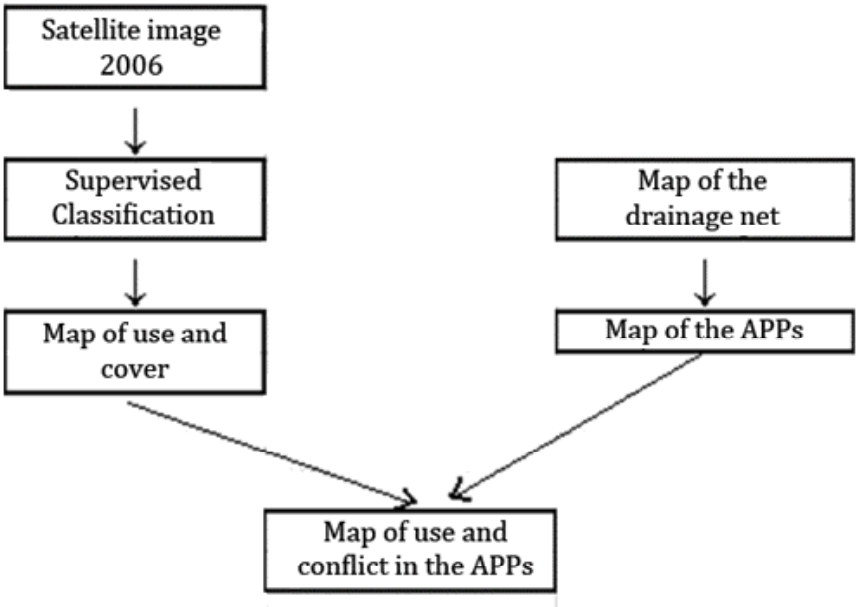

Figure 1. Methodological flowchart to determine the areas with conflict of use in APPs.

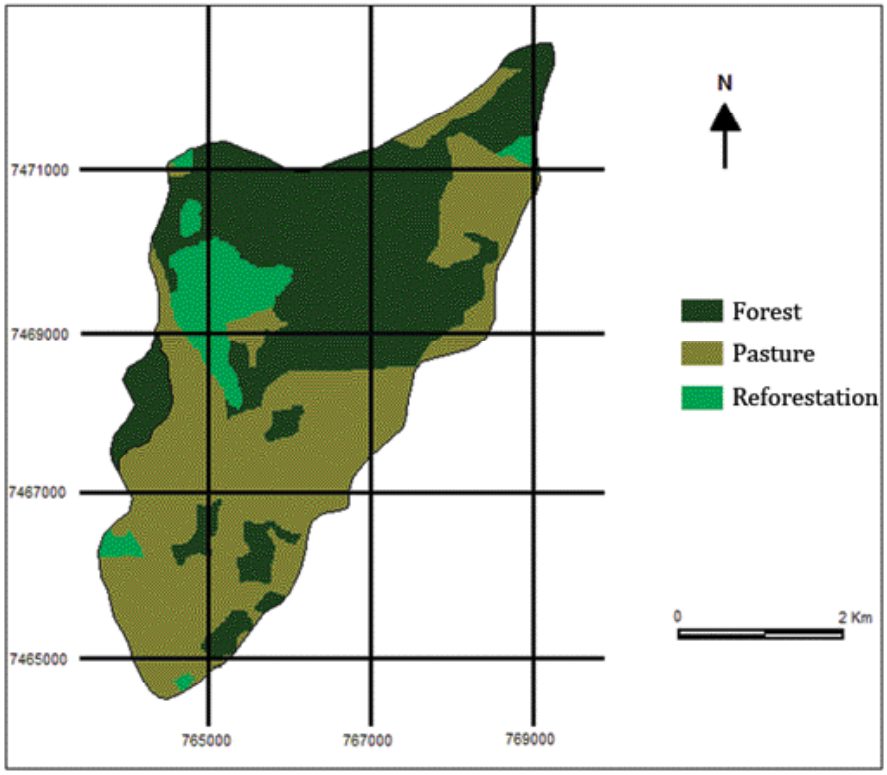

Figure 2. Land occupation of the Ribeirão Descalvado – Botucatu (SP) watershed, obtained in aerial photography from 1962.

Table 1. Land use in the Ribeirão Descalvado – Botucatu (SP) watershed.

Land use	1962		2005	
	ha	%	ha	%
Forest	949.42	46.29	395.99	19.32
Reforestation	210.40	10.25	135.86	6.62
Pasture	891.31	43.46	1398.58	68.18
Others (urban expansion)			120.70	5.88
TOTAL	2051.13	100	2051.13	100

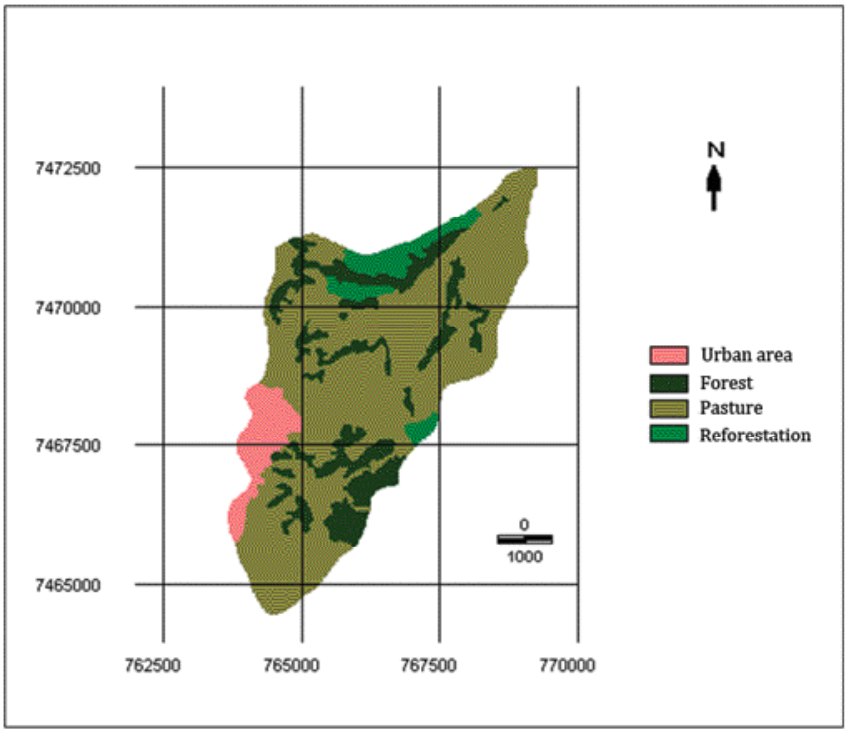

Figure 3. Land occupation of the Ribeirão Descalvado – Botucatu (SP) watershed, obtained in aerial photography from 2005.

achieves not only the economical necessities, but is also a form of protection against the erosive process, since for VIEIRA (1978), this vegetal cover has great influence in the process of flow, acting in the water mechanism, delaying and diverting the runoff and consequently the erosion.

Reforestation for CAMPOS (1997) must be increasingly improved in the region as a form of integrated rational protection of the area, mainly, because this activities show great economic returns for the region.

The forests and pastures covering almost 90% of the area covered by the watershed is a reflex of the predominance of soils with low fertility, according to BARROS (1990) and CAMPOS (1993). The Brazilian Forest Code (1965) determines that the minimum forest reserve must be 20%. This is a very important parameter, since according to ROCHA (1991), the forests are fundamental in the control or erosion and flood, because when situated in appropriated places are fundamental in the recharge of the groundwater. The transformations in the vegetal cover happen in a dynamic war in the watershed, over time, with the region suffering changes in the

landscape in these last 43 years, characterized mainly by the expansion of pasture.

The data obtained allow an analysis over the environmental preservation of this area, once the Ribeirão Descalvado watershed has been preserved over the years, since forests are still 19.32% of the area. These are formed by riparian forests, cerrado zones and forest themselves. According to the Forest Code, the minimum reserve of forests must be 20% of the property area with three cover.

The value of the Kappa index (Figure 4 and Table 2) obtained in the comparison between the land uses obtained by satellite images (2005) and colorful aerial photography from 2005 (land truth) resulted in 0.41, classification seen as good, according to LANDIS and KOCH (1977).

After the delimitation of the drainage network, the APP areas were established, which correspond to 216.89 ha (10.57%) of all the watershed area (Figure 4).

Figure 5 and Table 3 show the areas of conflict of this watershed, where part of the areas of permanent preservation (39.07%) are being used with other aims, as: 0.49% are already directed to urban occupation; 33.33% to pasture; 2.59% to reforestation and 2.66% to area of floodplains. The rest of the area, about 60.93%, maintain preserved the riparian forests in the appropriate proportions.

Conclusions

The panchromatic and colorful aerial photography and the satellite image enable the mapping of the land use in a reliable way, so that they will serve as data for future regional planning, as well as they show that the watershed is being environmentally preserved, since there is a small deficiency of forests (0.68%), since it is cover with almost 20% of forests, considering that the minimum required by the Brazilian Forest Code in force is 20%.

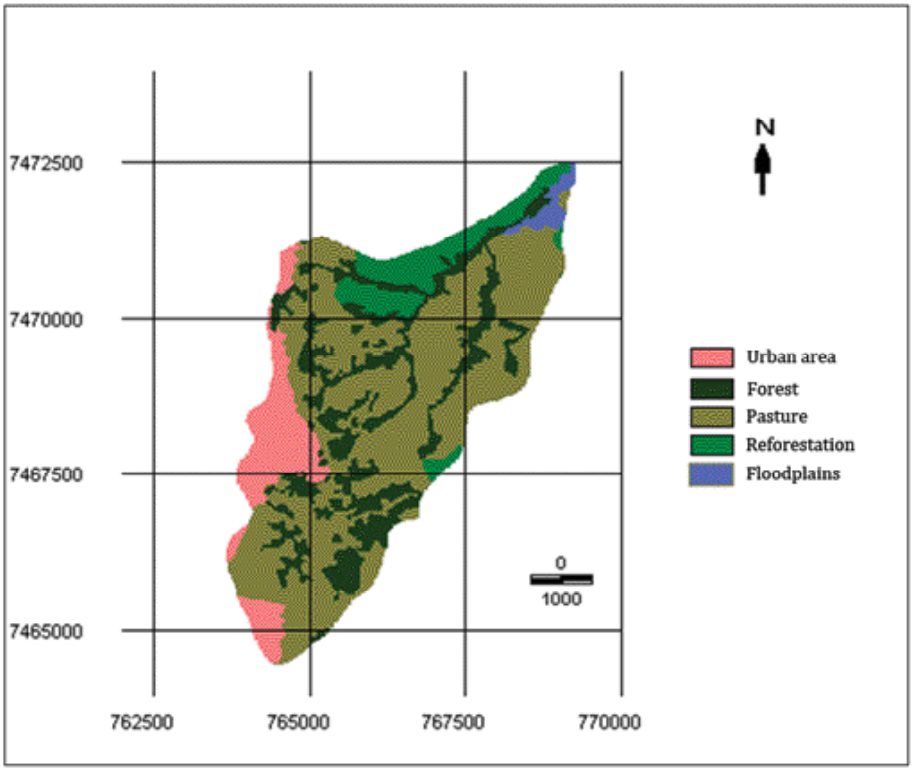

Figure 4. Land occupation of the Ribeirão Descalvado – Botucatu (SP) watershed, obtained in satellite images from 2005.

Table 2. Land use in the Ribeirão Descalvado – Botucatu (SP) watershed comparing satellite images and aerial photography to obtain the Kappa index.

Land use	2005			
	Aerial photography		Satellite image	
	ha	%	ha	%
Forest	395.99	19.32	451.49	22.01
Reforestation	135.86	6.62	181.38	8.84
Pasture	1398.58	68.18	1152.3	56.18
Others (urban expansion)	120.70	5.88	233.36	11.38
Floodplains			32.65	1.59
TOTAL	2051.13	100	2051.13	100

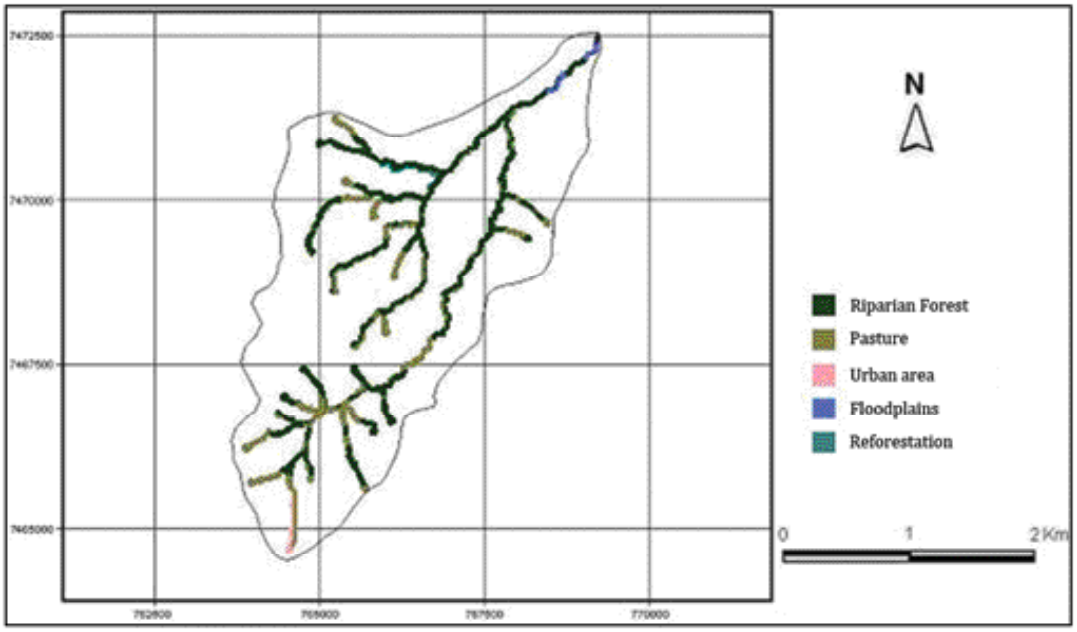

Figure 5. Conflict of the land use in APP areas of the Ribeirão Descalvado – Botucatu (SP) watershed.

Table 3. Conflict of the land use in APP areas of the Ribeirão Descalvado – Botucatu (SP) watershed.

Land use	Conflicts	
	ha	%
Urban Area	1.08	0.49
Riparian Forest	132.16	60.93
Pasture	72.29	33.33
Reforestation	5.61	2.59
Floodplains	5.75	2.66
Total	216.89	100.00

The high index of land occupation by pasture in the watershed (68.18%) shows the predominance of the local cattle and the presence of soils with low fertility.

The APP areas are not in good proportion to the watershed, since only 60.93% of them are occupied by riparian forest.

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