

Resumen

En el presente estudio se investigan los cambios que ocurrieron en la cobertura forestal de Costa Rica, desde la iniciación de la colonización española en el siglo XVI hasta el presente. Se hicieron los cálculos por medio de un modelo matemático sobre el período 1943-1977 y se hicieron estimaciones acerca de períodos anteriores. Se presentan los resultados en forma de cuadro. Se examinan brevemente los efectos y la reacción a la deforestación.

Introduction

The present paper endeavours to quantify the disturbance of the forest cover of Costa Rica by human activity throughout history, or since the conquest of the territory by Spain in the 16th century. The period 1943-1977 is fairly well documented in the literature, and mathematical models have been applied in the article to reflect the land use patterns during this time. Estimates are made for the period pre-1943 and these depend on certain assumptions which are outlined. Costa Rica is in an advantageous position in that much had been written and recorded about the country when most deforestation took place and it should be possible to refine these estimates with a closer study of the existing information.

Before 1800

Costa Rica may be divided for convenience into four: the Pacific Coastal Plains; the Caribbean Lowlands (including the plains of San Carlos and Sara-

piquí), and the Central Chain of mountains or Cordilleras, and a depression within the mountains known as the Central Valley. The latter is not a valley in the true sense of the word, but rather it is made up of several valleys. The River Reventazon drains the eastern portion of this depression and the Rio Grande Tárcoles drains the western part.

Spanish colonizers arrived in the dry Pacific north western lowlands in the early 16th century, but it was not until the 1560s that they managed to penetrate the Central Valley. Here, where the climate is milder, they located Cartago, the principal city of the province in 1563. The population was concentrated in and around this area throughout colonial times.

In the absence of man's interference almost the whole surface area of the country would be under some form of forest cover with the exception of open water surfaces, lava outflows and the 'paramo' or the cover of vegetation above the tree line. According to Sylvander (13) the following are non-forest areas, other than paramo, given in percentage of total surface area of the country in 1977:

Swamp without forest cover	1.9%
Water	0.5%
Other types	0.5%
	<hr/>
	2.9%

Found mostly at elevations above 3 000 m, paramo constitutes about 0.6% of the country; when added to the above, a non-forest area of about

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* Research Branch, Forest and Wildlife Service, Sidminton Place, Bray, Co. Wicklow (Ireland).

3.5% results and it is assumed here that this figure remained more or less constant throughout history.

Man had inhabited Costa Rica long before the coming of the Spanish and had disturbed the natural vegetation in many ways. He probably had much effect on most or all Middle American vegetation at some time (16). However, the area cleared of forest cover in Costa Rica when the Spanish arrived, is thought to have been very small. Tosi (14) estimates that this would not have been more than 2%.

The total population of the country fell from about 27 000 at the outset of the colonial period to an all time low of 15 500 around 1611 (Figure 1). Thereafter it began to increase and reached 52 000 or thereabouts by 1800 (2).

It is natural to presume that forest clearance accelerated when the colony was first established and when the two cultures, Indian, and Spanish

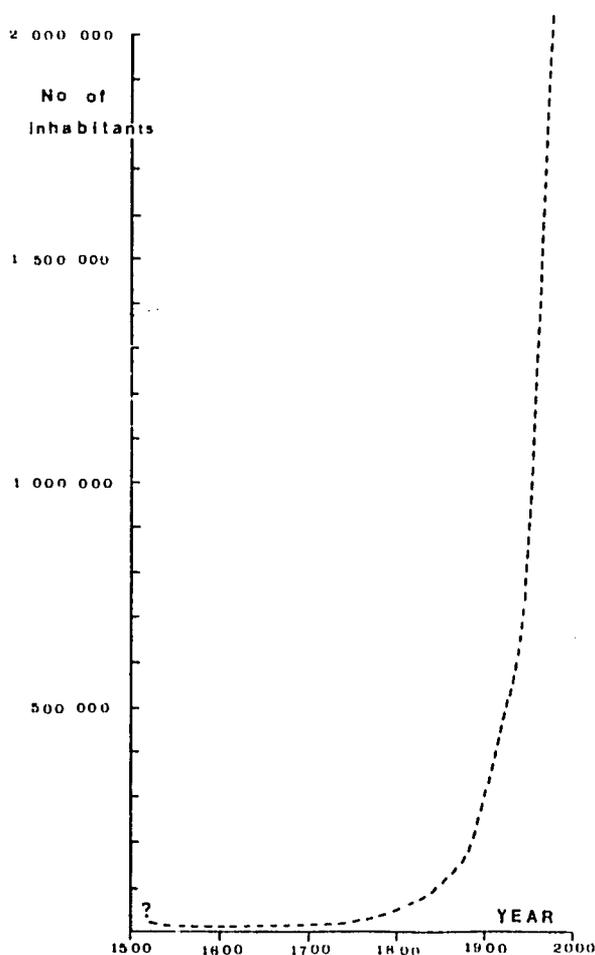


Fig. 1. Population of Costa Rica 1522-1977. Based on, Dir. Gen. Est. (3) and Costa Rica (2).

with their influx of cattle, were competing for the cleared areas. As the population decreased it is likely that the total area of land cleared remained stable or even decreased.

Forest expansion would have occurred anywhere there were abandoned areas in which natural regeneration was not hampered. So the first quarter of the 17th century may have seen the greatest extent of forest cover since the outset of the colony to the present day.

It is difficult to be more specific about the period pre-1800. After 1800, and especially after independence in 1821, the picture of forest clearance is somewhat less hazy. More reliable data is available from 1943 to the present and it is proposed to examine this interval first.

The period 1943-1977

A considerable amount of data exists for this time. In 1943 the U.S. Department of Agriculture produced a report on the forest resources of Costa Rica. National agricultural censuses were carried out in 1959, 1955, 1963 and 1973 and these include data relating to forest cover. Forest cover maps were produced for 1961 and 1977. Tosi (14) studied the forest resources of the country with special emphasis on the years 1950 to 1973 and Perez and Protti (9) made a survey of the forest sector during the period 1950-1977. The Central Bank of Costa Rica have also produced relevant data.

As techniques improved through the period, land use patterns and their areas were determined with greater accuracy: aerial photography has been applied increasingly since the 1940s and Sylvander (13) made use of satellite images.

In this paper three broad land use categories are recognised: agriculture, forestry and other. If two of these categories are known for any point in time, the third may be deducted by subtraction from the total surface area of the country (some 51 100 km²). Land devoted to agriculture includes pastoral land, and land under permanent and temporary crops like coffee, cacao, bananas, cotton, maize, beans, etc. In addition, fallow land, scrub land (charral) and savanna are included in this group.

The definition of forest in the literature is not compatible in all cases where forest cover has been estimated or measured; for example areas with trees under five metres tall whose crowns cover less than 50% of the ground are excluded from the forest category by Sylvander (13), but may have been

accounted for by other workers. Nevertheless, the definitions should be sufficiently close, as they stand, to reflect adequately the pattern of deforestation through the period.

In the previous section the assumption was made that the area of non-forest surfaces, other than those created by man, was about 3.5%. This makes up the bulk of the category denominated 'other', but to this must be added the urban areas, including the communications network. Sylvander (13) estimated an urban area of 0.6% for 1977, with an error of estimate of 63%. This is a very large error for a very small surface area. In order to account for this category through the period it was presumed constant at 0.6%. For other periods, the urban area is assumed to be insignificant and no attempt is made to estimate it.

Figures for the area of agriculture or forest land or both were taken from Sylvander (13), Tosi (14), Cepal *et al.* (1), the Forest Cover Map of 1961 (5) and U.S. Department of Agriculture (15). Data that were not the original work of the authors were based on the agricultural census or information from the Central Bank. Some adjustments were necessary in order to separate the data into the categories outlined above. Nine estimates of the total area occupied by forest resulted one observation for each of the years: 1977, 1975, 1973, 1971, 1963, 1961, 1955, 1950 and 1943. An equal number of observations were available representing the percentage land under agriculture for the same years.

A polynomial equation was fitted to the nine observations in each category. The equation type is:

$$1) \quad Y_e = a + bX + cX^2$$

where Y_e = estimate of cover category, as percent of the total land surface area of Costa Rica.*

X = Year (1977 is year 0; 1976 is year 1; and X ascends for other years prior to 1976)

a = intercept

b and c = regression coefficients

The least squares method was used to estimate the equation for each category and the results are as follows:

$$2) \quad Y_e = 41.71 + 1.5243(X) - 0.0147(X^2)$$

where Y_e = percentage of Costa Rica covered by forest

X = as in equation (1)

$$3) \quad Y_e = 54.17 - 1.5243(X) + 0.0147(X^2)$$

where Y_e = percentage of agricultural land

X = as in equation (1)

These equations fit the observations very well (the coefficient of determination (R^2) in both cases is 0.99). However, because of the nature of these models, it would be extremely risky to extrapolate them.

Equation (2) suggests that the percentage forest cover in Costa Rica in 1943 was 76.54% and in 1977 41.71%, thus the overall rate of deforestation in the period was about 52 000 hectares per year. The equation points to an ever-increasing speed of forest clearance. However, there is certain evidence to suggest that the rate may have reached a maximum of 70 000 hectares and has begun to subside somewhat (13).

The year 1 900

During the period 1943-1977 the population increased from 687 000 to 2 044 000 (3) and according to equation (3), the total area devoted to agriculture rose from 9 881 km² in 1943 to 27 681 km² in 1977. From these sources, the agricultural area in ha/capita was calculated for the years 1977, 1943 and every five years from 1950 to 1970 inclusive. A straight line regression was fitted by the least squares method to the figures and the following equation was produced:

$$4) \quad Y_e = 1.34 + 0.0041(X)$$

where Y_e = is an estimate of agricultural land in ha/head of population

X = year, as in equation (1)

Equation (4) shows a tendency for the ratio of agricultural land per head to decrease slightly from 1943, which suggests a more efficient use of land through time. The assumption is made here that this process had been going on through the present century. If so, equation (4) indicates that the ratio would have been 1 656 ha/head of population for 1 900 ($X = 77$). In that year, Costa Rica had a population of 303 760 (2), and therefore an esti-

* The dependant variable was expressed as a percentage rather than a transformed value. Transformation was not necessary, mainly because most of the original data lay between 30 and 70%.

ated agricultural land area of 5 030 km² or 9.8% of the country. The result agrees with an estimate made by Tosi (14) in that less than 10% of the national territory would have been under agriculture. Besides this, 3.5% was in the category 'other' and therefore the forest cover was about 86.7%.

Although the conclusion appears reasonable, such a calculation must be treated with caution because of lengthy extrapolation of equation (4) and a more detailed study is necessary to refine the estimates. However, agriculture in 1900 was not very different from that practised at the beginning of the period 1943-1977, nor would the rural/urban population balance have changed greatly, so that the estimated agricultural area may be, if in error, exaggerated. The result suggests an overall deforestation rate of over 12 000 ha/year between 1900 and 1943, less than a quarter that of the period 1943-1977 as estimated by equation (2).

The year 1 800

Less than 10% of Costa Rica was divided into private property at the beginning of the XIX century and although no agricultural census exists for this time it is possible to limit the area on the basis of information of land transactions in the records (4). This area is divided by Hall (4), into five regions, each containing a different land use pattern. The rest of Costa Rica was 'tierra baldia' (crown land during the colonial period or national land after independence), which was practically all under forest (Figure 2).

The five regions of the private property area were not all cleared of forest at the beginning of the XIX century; the region of cacao production (region 1) on the east coast would have been heavily forested as well as the area that had been bought by speculators (region 3). In fact, outside the main population concentration, an area of about 600 km² (region 2), and a zone of large haciendas (region 5), very little land had been deforested. There was another area of about 350 km² to the west of region 2 in the Central Valley (region 4), where forests were of about 350 km² to the west of region 2 in the Central Valley (region 4), where forests were probably as extensive as grazing land.

If it is assumed, then, that all of region 2 and half of region 4 were cleared of forest, this could result in a cleared area of about 1.5% of the country.

Region 5 in the north west was possibly greater than 3 660 km² in extent, where livestock were raised in large haciendas. Extensive grazing was practiced and much of the zone was under forest;



Fig. 2. Land use in Costa Rica C. 1800. Based on Hall (4).

savannas were also present. The savannas were thought to have been man-induced at some point in the past.

It is difficult to be precise about the proportion of land under forest in region 5 at the beginning of the XIX century. In 1977 the forest cover here was about 18% as estimated from: Min. Agr. Gan. (8) and in 1961 it was about 34% as estimated from Instit. Geog. Nac. (5). This indicates a forest cut back of over 36 km² per year. It was assumed that removal prior to 1961 was proportional to the national rate; thus the area of forest in 1900 was calculated to cover 53% of the region and the rate of felling at the turn of the century was estimated to be about 6.7 km² per year. If this rate had continued through the XIX century an extra 670 km² of forest would have been added, bringing the total area covered, in 1800, to about 71% of the region. The rate of deforestation in the XIX century would not have exceeded 6.7 km² per year, but may have been less and so it is difficult to be more precise than to assume the forest cover was between 53 and 71% in 1800; in other words, the open area lay between 29 and 47% of the region or 2.0 and 3.4% of Costa Rica.

In summary, in 1800 there was a cleared 'agricultural' area of between 3.5 and 4.9% of the country (mean of 4.2%) and a forest cover of between 91.6 and 93.0%. This would suggest an annual rate of deforestation of less than 3 000 ha per year, about a quarter that of the period 1900-1943. Further, most of the clearance would have taken place after 1850. This may be deduced from the proportion of

claims for 'tierras baldias' before and after 1850 in the National Archives, the growth in population (Figure 1) and the pattern of colonization of new areas by the expanding population (11).

Summary 1 500 -- 2 000

Table 1 summarizes the probable pattern of land use through time, while Figure 3 shows how the forest cover was removed since 1800. By far the greatest amount of deforestation took place in the period 1943 - 1977 for which most data are available. In fact, more forest cover was removed in this period than in the previous 400 years. The estimates, particularly pre-1943 are tentative; it may be possible to refine them with a more detailed study of existing records but I doubt that the overall pattern would be altered greatly.

If the destruction of the forest resource was to continue uninhibited at the present rate, then Costa Rica would be without forests by the end of the first quarter of the XXI century.

This enormous rate of removal is not accompanied by a parallel utilisation of the timber. Much of the wood is burnt or left to rot on the ground and most of the land eventually passes to grazing. The explosion of the area under grazing, especially since 1950, has contributed largely to the destruction of the country's forests and is seen as a source of quick monetary return but may be a long term fiasco (10, 12, 14).

Discussion

The dramatic decrease in the area of natural vegetation, especially in the last 40 years, has had many

Table 1. Pattern of land use in Costa Rica from the conquest to the present day, in percentage of the total surface area of the country.

Year	Land Use Category		
	Agriculture	Forest*	Other
Early 16th century	2.0	94.5	3.5
1800	4.2	92.3	3.5
1900	9.8	86.7	3.5
1943	19.4	76.5	4.1
1960	32.5	63.4	4.1
1977	54.2	41.7	4.1

*Includes natural forest only; the extent of planted forest is insignificant.

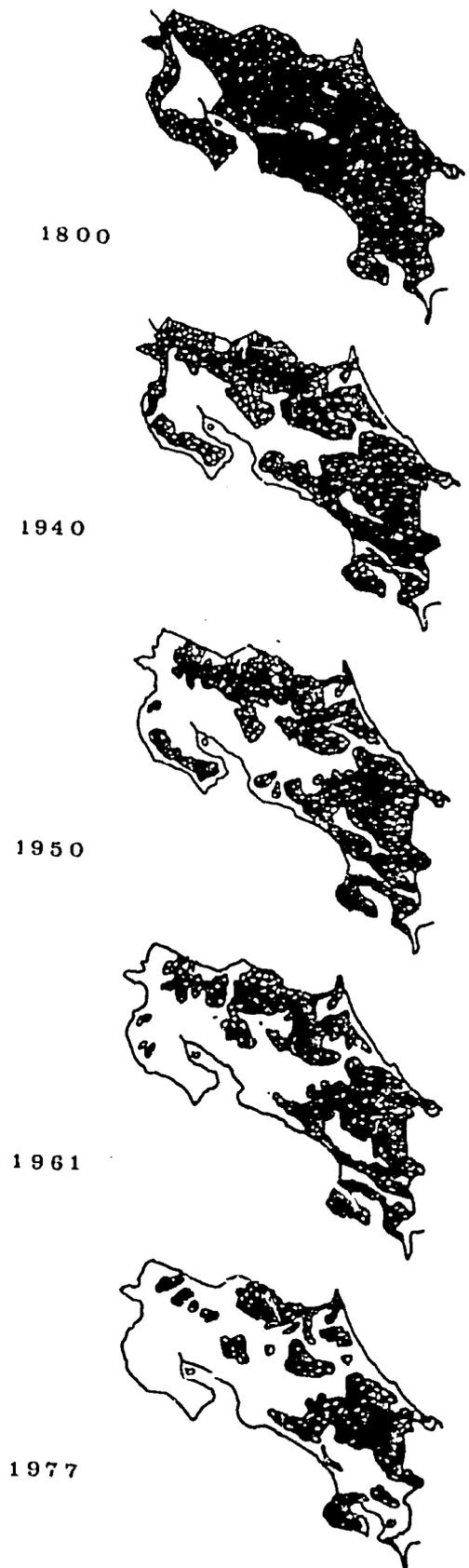


Fig. 3. Forest cover of Costa Rica for selected years, based on Hall (4), year 1800, and Perez and Protti (9).

side effects on the environment. Erosion of unstable soils, particularly on sloping ground has increased; the stabilizing effect of the forest on watershed has been decreased and an appalling destruction of wildlife, wildlife habitats and flora has taken place. This has caused concern among conservationists and politicians.

The Government of Costa Rica has taken steps to control the indiscriminate felling of trees. A forest law was passed in 1969 to protect and use rationally the natural forest resources of the country (6). A reforestation law came into effect in 1977 (7) that encourages, through incentives, landowners to create forests by planting. National parks and forest reserves have been set up all around the country to preserve areas of scientific interest, and to protect flora and fauna from extinction, and to promote rational exploitation of the forest. It is too soon to comment on the long term effects of these measures but it is encouraging to see that steps are being taken in the right direction.

The next 30 years will be crucial for the natural forest resource of Costa Rica: whatever will be preserved will be preserved in this period and so it would be helpful to have continued surveys of the forest cover undertaken. These would help to assess the success or otherwise of the government measures and further corrective action could be taken if necessary.

Summary

An attempt is made to trace the changes that took place in the forest cover of Costa Rica, from the coming of the Spanish in the 16th century to the present day. A mathematical model was compiled for the period 1943 - 1977 and estimates were made for periods prior to this. Results are summarised in the form of a table. Effects of and reaction to the rate of deforestation are examined briefly.

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Reseña de libros

BULLOCK, A. y WOODINGS, R. B. eds. The Fontana biographical companion to modern thought. London, Fontana, 1983. 867 p. \$ 6.95 en rústica.

Cuando el admirable *Dictionary of modern thought*, de Bullock y Stallybrass, apareció en 1977, fue aclamado universalmente como una obra-enciclopedia de todos aquellos términos con que uno se tropieza en la esfera del pensamiento moderno, interpretado en forma amplia: no sólo filosofía, arte y ciencia, sino también política, sociología, educación, religión y cualquier otra cosa con que nos topamos en nuestras lecturas y que no ha alcanzado todavía un sitio en las enciclopedias usuales. Vocablos como "tremendista", "euritmica", "programación lineal", "oligopolio", "teoría de la caja negra", etc. Las entradas se relacionaban principalmente con abstracciones, instituciones y conjuntos de conceptos. Si me refiero a este primer libro es porque la gran acogida que tuvo originó este segundo volumen que lo complementa. También hay el hecho de que creía haber escrito una reseña recomendándolo, pero ahora veo que sólo hice unos apuntes que nunca completé.

Cuando se elaboró el diccionario, los editores tuvieron que aceptar que era imposible, por razones de espacio, incluir entradas biográficas; se limitaron, entonces, a poner sólo nombres y fechas, con referencias a las ideas y temas en las que tuvieron influencia. Se decidió esperar, y si el diccionario tenía éxito, se prepararía un volumen independiente, pero complementario, que presentaría la información biográfica, difícil de obtener, que cualquiera pueda necesitar al explorar el pensamiento moderno. Porque nadie puede, por ejemplo, estudiar física moderna sin saber quienes fueron Kamerlingh Onnes, Niels Bohr, Heisenberg, Rutherford, Schrödinger, y cuáles son las diferentes contribuciones que ellos han hecho; o, para tomar un puñado de nombres de la biología,

quienes fueron Eigen, Niko Tinbergen, Monod, Cornforth, Krebs, Vavilov, Watson y Crick, y con cuáles progresos están asociados. Es sorprendentemente difícil obtener respuestas satisfactorias para las figuras que han destacado en los últimos veinte o treinta años en los campos del conocimiento que menos publicidad reciben.

Por "moderno" se quiere decir, en este caso, el período desde 1900 hasta el presente. Esto excluye a casi todos los que murieron antes del siglo actual. Las excepciones son un pequeño número de figuras notables, tales como Marx, Babbage, Kirkegaard, Mendel (el centenario de su muerte se cumple este año) quienes, aunque sus fechas corresponden al siglo diecinueve, sus logros se han aprovechado, o se han reconocido en este siglo como contribuciones claves al pensamiento moderno.

El trabajo conjunto de los editores, consultores, especialistas y redactores, resultó en que unos 300 colaboradores escribieron unas 200 entradas. Pero la meta fue producir algo más que un *Who's Who*. Para llegar a la cifra final de 1945 entradas, el factor decisivo fue el grado en que un individuo que trabaja en un campo particular ha modificado la misma definición de su campo y su subsecuente desarrollo, y sigue siendo una presencia que se debe tener en cuenta por sus continuadores. También hay otro tipo de personas que han tenido influencia en el mundo moderno. Unos, la mayoría, por sus contribuciones a la literatura, religión, filosofía, las ciencias naturales y sociales, así como a la música y las artes visuales. Unos pocos gozan de una existencia simbólica como representantes de un punto de vista o estilo de acción distintivos. Esta existencia simbólica es aún más relevante para los actores, ya sea del teatro, cinema o sala de conciertos, algunos de los cuales (Casals, Chaplin, Marilyn Monroe) son ya leyendas.

El examen de este libro, que a ratos se vuelve fascinante, nos deja la impresión de que va a ser difícil mantener que el siglo veinte no ha alcanzado la energía creadora y el genio de las edades que lo han precedido. También aparecen, al recorrer sus páginas, cier-