Whitetail Deer Food Availability Maps from Thematic Mapper Data

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ABSTRACT: A map indicating potential food availability for whitetail deer was prepared from Landsat 4 Thematic Mapper (TM) data. Land-cover information was derived from the TM data using an unsupervised classification technique, compared with digitized ground truth, and input to a Geographic Information System (GIS). The GIS delineated regions around land covers classified as escape cover, producing a "distance map." Relative food values assigned to the classified forage categories when combined with the "distance map" produced the food availability map. The habitat suitability value for the entire study area was determined to be 0.34 on a scale from 0.0 to 1.0. In comparison, two approximately four square mile subareas, one with a high concentration of deer and the other with a low concentration, resulted in habitat suitability values of 0.48 and 0.16, respectively.

INTRODUCTION

THE MAIN OBJECTIVE of this study was to determine the capability of TM digital data to provide land-cover information for input to a whitetail deer (*Odocoileus virginia*) habitat suitability model. This model has been developed for the U. S. Army Corps of Engineers (COE) (Armbruster *et al.*, 1987) and will be used to evaluate the potential impacts associated with the Corp's flood control projects as well as a wildlife management tool. With the latter in mind, it was important to know whether the TM data could be processed using standard methods and software and with sufficient accuracy to delineate land cover (corn, wheat, sugar beets, soybeans and other beans, wetland grasses, pasture, etc.) necessary for evaluation of food potential and escape cover (woody and non-woody vegetation such as forest, shrub, and cattails) for application of that model.
1 October of each year. The manager's job involves assessing deer habitat in terms of areas and mixes of species and age classes of vegetation. Presently, land-cover data are acquired either through ground surveys or from cover maps prepared from aerial photographs. The cover types are normally only prepared for state-owned lands which limits aerial coverage (Roller *et al.*, 1980). The U.S. Fish and Wildlife Service recommends the use of topographic maps and high altitude color infrared (CIR) photographs to delineate land cover in their Habitat Evaluation Procedure (HEP) (Lunetta *et al.*, 1985). The value of an area, as a habitat, is dependent upon the arrangement of various vegetative cover types. To effectively evaluate an area, the manager needs sufficient spatial distribution information. Typically, this information is sketchy and inconsistent (Roller *et al.*, 1980).
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The need for relatively quick and potentially less expensive ways to compile habitat information has led to the use of high resolution satellite data (Isaacson *et al.*, 1982; Ormsby *et al.*, 1985). Payne and Long (1986) adapted an existing Habitat Suitability Index (HSI) model such that certain variables defined from the remotely sensed data were substituted for appropriate model variables. Roller (1978), Joyce (1979), Mead *et al.*, (1981), and Lyon (1983) developed models based on land-cover types and their spatial relationships. These models were computer-based and used data obtained from aerial photographs or remote sensor data. The major advantages associated with remotely sensed data are time savings, capability to reproduce or update surveys, and, with the aid of a Geographic Information System (GIS), to manipulate the data to illustrate relatively complex spatial habitat relationships such as interspersion and juxtaposition (Wheeler and Ridd, 1984; Lunetta *et al.*, 1985). Techniques to measure interspersion and juxtaposition are described by Roller (1978), Mead *et al.* (1981), and Heinen and Cross (1983).

BACKGROUND

FOOD AVAILABILITY MODEL

A Habitat Suitability Model for whitetail deer (Armbruster *et al.*, 1987) was developed for the U.S. Army Corps of Engineers' Detroit District and Waterways Experiment Station. The model's application is oriented around land-cover types as they relate to food resources and escape cover, the critical habitat components. Actual areal coverage and cover type location are necessary prerequisites to model application. Once this is completed, the winter and spring food value and value of escape cover can be estimated for the entire area. According to the model, ideally, 35 percent of a potential habitat area should be devoted to some form of escape cover well interspersed with food supply. Optimum food conditions exist if 65 percent of the area supplies food with an equivalent value of 1.0 (Armbruster *et al.*, 1987).

Application of these spatial relationships can be achieved through manual techniques or, as described here, through the use of a GIS. The basic white-tailed deer model, utilized in this study, has since been translated into a computer based model by the Corps' Waterways Experiment Station. Incorporated into the computer model are distance relationships required to perform interspersion and juxtaposition analysis. Habitat variables derived from Landsat TM data, medium altitude aerial photography, and limited field data collection have been assembled into a layered GIS. The computer based model can exploit the data base through GIS to access habitat variables and to determine spatial relationships between variables. Operating in the GIS environment provides two-dimensional geographic information with a high degree of precision and speed that cannot be achieved using manual techniques.

STUDY SITE

A 194 sq km (75 sq mi) subbasin of the Saginaw River was chosen for study (Figure 1). Included in the study area are the Shiawassee National Wildlife Refuge and the Shiawassee River State Game Area. This area has a wide range of land cover consisting of floating and emergent macrophytes, shrub/old field vegetation, forested wetlands and uplands, rangeland, wetland grasses, agricultural lands, and open water (Lunetta *et al.*, 1985).

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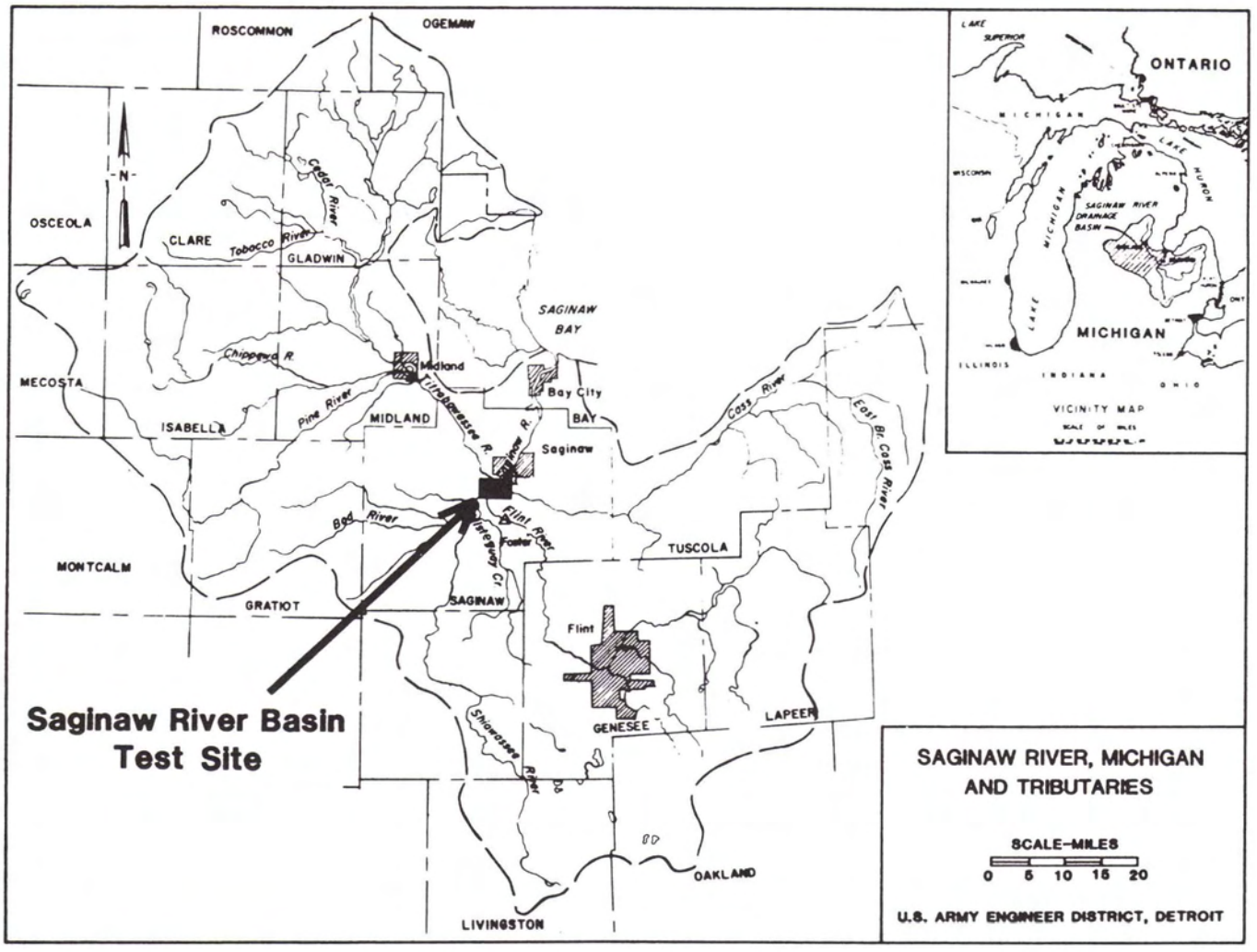

FIG. 1. Map showing location of study site.

The area was specifically chosen because of the heterogeneity of land covers and field sizes and shapes, thus providing a good test for the TM data for land-cover analysis related to habitat evaluation. In addition, records pertaining to agricultural land usage were readily available for the government land areas.

METHODS

A Landsat 4 TM scene (17 August 1982, 40032-15422) was chosen for the initial land-cover analysis. Because a true "winter" scene was not available, this scene was used and assumed to represent the mid-December to mid-March or "winter" period described by the model. Additional data included approximately 1:24,000-scale panchromatic photographs (17 June 1983) and CIR aerial photographs (1 September 1983), 7 1/2-minute quadrangles, and 1982 crop data from the Saginaw County Agricultural Stabilization and Conservation Service (ASCS). Additional ground truth data were obtained during the summer of 1983, concurrent with the aerial photographs.

The 1982 ASCS data were used to compile a crop/land-cover map to compare with the TM data. Base maps were digitized and the product was called Ground Verification Data (GVD). Data on specific crops grown on private farmland are generally not compiled by the ASCS, so these areas were indicated as general agriculture (crops).

The Electromagnetic Systems Laboratory (ESL) IDIMS (Interactive Digital Image Manipulation System) software package ISOCLS, an unsupervised classifier, was used to generate 64 clusters. ISOCLS partitions a given set of multivariate data points, with little or no knowledge about the actual distribution of the data, into disjointed sets of "similar" data points. The classification began with the assumption that all the data were one cluster and proceeded with a series of "split" and "combine" iterations until the maximum number of iterations/clusters were reached (ESL, 1976). The land cover represented by each cluster (Plate 1) was identified based on ground truth provided by the COE.

An accuracy assessment was done to provide some degree of confidence in the map prepared. The digitized GVD were registered to the classified TM data. A confusion matrix between the GVD and the classified TM data was evaluated using the IDIMS program CONTABLE. The values along the diagonal of the matrix indicate agreement between GVD and the classified image categories. These values divided by the totals for each row category (GVD) provided a percent agreement based on the GVD.

The spatial distribution of land cover generated from the TM data was used as input to GIS software developed and modified at Goddard. The GIS programs were used to denote the food potential of the land-cover categories in relation to distance from escape cover based on information provided by Armbruster *et al.* (1987). In the model, escape cover consists of non-woody wetlands, woody vegetation less than 1.5 metres in height, woody vegetation greater than 1.5 metres, and linear features, such as fence rows and ditches (Armbruster *et al.*, 1987). Escape cover areas smaller than 0.4 ha were considered to have no escape value. Because one TM pixel is equivalent to 0.09 ha, isolated forest pixels were removed using the IDIMS routine NEIGHBOR. While clusters assigned to other cover types were assumed to

provide escape cover, for this demonstration only the forest category was adjusted to eliminate isolated pixels. In fact, the clusters assigned to the cattail, shrub, and forest categories were assumed to be escape cover.

The area surrounding the escape cover was then separated into zones (Plate 2) each 0.40-km (0.25 mile) wide. This distance is represented by approximately 13 TM pixels. Each zone was weighted based on the distance from or to escape cover. For example, the first zone around the escape cover received a value of 1.0. Each succeeding zone, 0.4 km in width, received a lower value (0.75, 0.50, and 0.25), respectively. No weight was given to cover types in excess of 1.6 km from escape cover.

A food value was assigned to each agricultural land-cover category based on the winter food values given by Armbruster *et al.* (1987) and shown in Table 1. Any urban area was assumed to be of limited value to the animal and given the value zero. The weighted food value for each cover type was multiplied by the distance weight to determine the equivalent food potential. A map was then created using the GIS program OVERLAY which derived the relationship between distance from escape cover and the equivalent food potential of the category in the particular distance zone (Plate 3).

RESULTS

Using land-cover designations based on Anderson *et al.* (1976) and the IDIMS program COMPARE, the agreement between the GVD and the classified land-cover data was determined. Percent agreement was obtained by dividing the number of correctly classified pixels for each land-cover class by the total number of pixels for the land-cover class identified from the ground truth. The scene agreement was obtained by adding the individual category agreements along the diagonal and dividing by the total number of pixels.

The overall agreement between the GVD and the classified data for the Level I categories was 73 percent. In the agricultural areas where the land-cover classes were most discernible, the Level I agreement was 90 percent (Table 2). The more specific categories of a Level III type classification (Table 3) resulted in a 67 percent overall agreement. The agreement between specific categories such as beans (beans and soybeans combined) was 84 percent, while the sugar beet category showed a 76 percent agreement. Corn's accuracy was 71 percent, the corn category being confused with mixed wetland grasses, beans, and forest. While the agreement was less than expected, the causes are not new (Jaynes and Willie, 1982). The GVD categories were more specific than those assigned to the classified TM data. This created a mismatch between certain GVD categories and the TM categories. Also, ambiguous cover classes were interpreted differently by the two study groups (those preparing the GVD data and those classifying the TM data).

TABLE 1. WINTER FOOD AVAILABILITY FACTORS (FAF) FOR LANDSAT DERIVED CATEGORIES

Cover Type	FAF
Corn	0.80
Beans and beets	0.15
Pasture	0.10
Wetland grasses	0.10
Wheat	0.05

DISCUSSION

The critical factors considered by the whitetail deer habitat suitability model are the availability of winter and spring food and their relation to escape cover. This study demonstrated the use of Landsat-4 Thematic Mapper data to provide land-cover information and the use of a GIS for manipulating the data to prepare a map showing the value of potential food sources in relation to escape cover. The food availability map could provide managers with information needed to assess how changes in an area may affect deer habitat. The map (Plate 3) shows areas ranging from high to low food potential based on the equivalent food potential of the cover type modified by distance from escape cover. The best food source in relation to escape cover was corn. Wheat, with its lower equivalent food potential, provided the least acceptable areas.

To determine the habitat suitability value of the study area, the percent area of each land cover shown in Plate 3 was obtained by taking a histogram of the data. The potential escape cover for the entire study area was 28 percent compared with an optimum of 35 percent specified in the model. This shortfall in area reduced the suitability index for escape cover from 1.0 to 0.8. Assuming a food availability factor of 0.8 for the escape cover, the overall value for escape cover was 0.18 (0.28 * 0.8 * 0.8). The percent area potentially usable (urban and water are removed from the area calculations) for browse was 72 percent. Because the optimum of 65 percent was reached, the suitability index remains at 1.0. This value is multiplied by the sum of the product of each land-cover area times its FAF times the "distance" weight. For the entire study area, this value was 0.16. The suitability value for the entire area was 0.34, the sum of the value for the escape cover and the value for the browse area (0.18 + 0.16). Using the same computational techniques, a habitat suitability value was computed for two areas, each approximately 10 sq km (4 sq mi). The area known to have a high concentration of deer had a value of 0.48 (area A, Plate 3) compared with a value of 0.16 for an area more sparsely populated with deer (area B, Plate 3).

The potential utility of such a food availability map lies in the information which is presented and the ease with which such a map can be prepared. Murray and Leckenby (1985) indicate that distance information probably is the most difficult to obtain and tabulate by the usual methods available to managers. In addition, visual presentation can be assimilated quickly by the expert and by the lay person.

Programs common to an image processing system can identify similar spectal areas which can be used to map most land-cover categories necessary for a habitat study (Isaacson *et al.*, 1982; Wheeler and Ridd, 1984). These data, along with a GIS, provide the tools with which one can provide valuable input to

TABLE 2. LEVEL I UNSUPERVISED CLASSIFICATION CONFUSION MATRIX

	Landsat 4 Thematic Mapper							
GVD	Wetlands	Crop Land	Forest	Water	Urban	Rangeland	Totals +	% Agree
Wetlands	27612	46739	21592	5577	2434	5339	109293	25
Crop Land	1401	394587	5509	292	22821	12133	436743	90
Forest	18459	29086	176105	1768	2364	5389	233171	76#
Water	25187	5454	8050	44676	732	3956	88055	51
Urban	25	3549	153	162	2643	2054	8586	31
Rangeland	1612	9366	3214	395	2800	9049	26436	34
Totals +	74296	488781	214623	52870	33794	37920	902284	73

GVD stands for Ground Verification Data. + The individual category totals as determined from the Landsat and the GVD are shown at the end of each column and row, respectively. # The shrub category was included in this category.

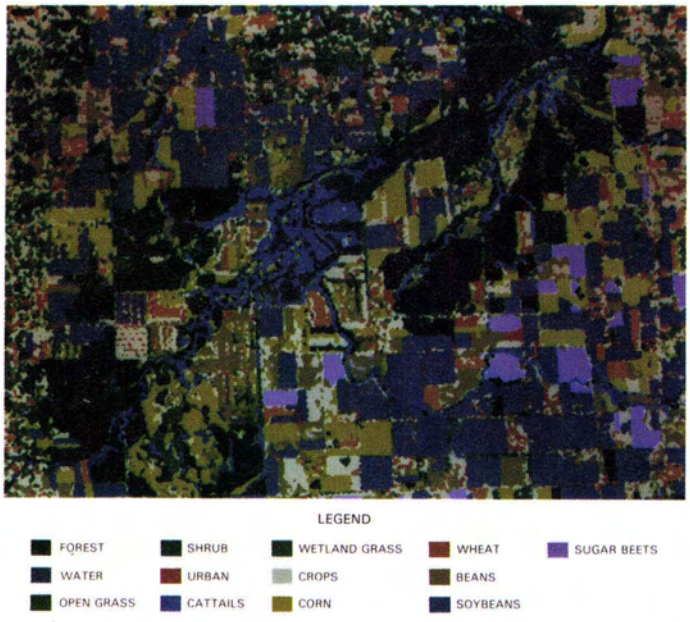

PLATE 1. Results of unsupervised cluster analysis using Landsat 4 Thematic Mapper data.

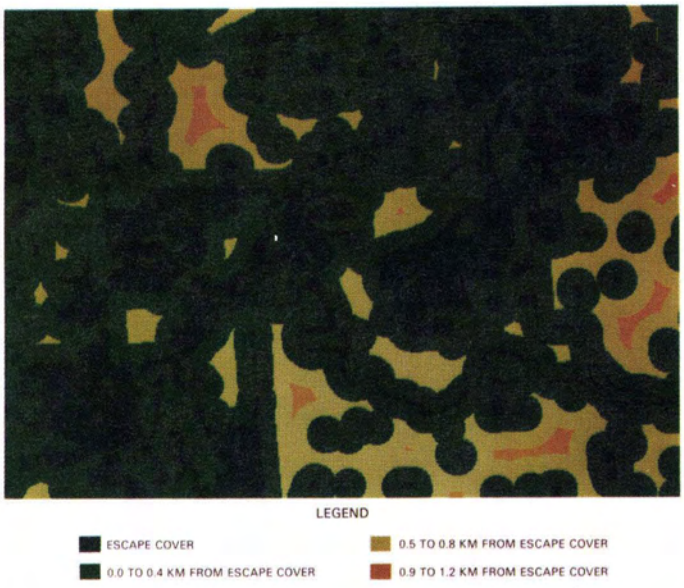

PLATE 2. Map showing zones around escape cover derived from classified TM data using a GIS.

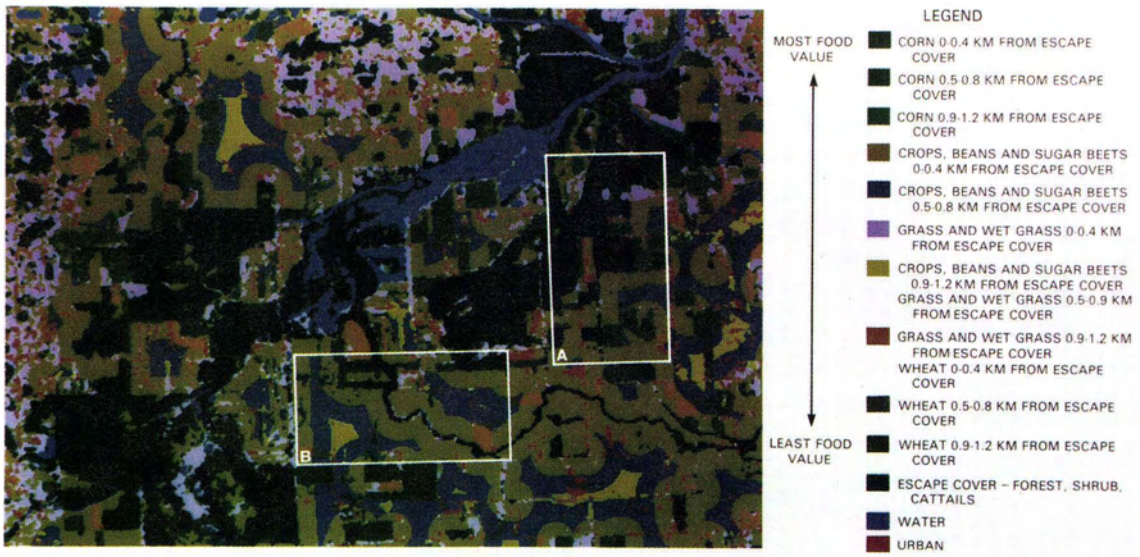

PLATE 3. Map depicting areas of potential food availability based on a land cover's food value and distance from escape cover. (A) Area of high deer concentration. (B) Area of lesser deer concentration.

TABLE 3. LEVEL III UNSUPERVISED CLASSIFICATION CONFUSION MATRIX

	Landsat 4 Thematic Mapper											
GVD	Cattails	Mixed Gr	Corn	Wheat	Beans	Sgr Bts	Forest	Water	Urban	Rangeland	Totals +	% Agree
Cattails	16743	1123	3430	58	986	85	9679	1139	107	797	34147	49
Mixed Gr	4920	4826	24482	51	17302	345	11913	4438	2327	4542	75146	6
Corn	171	192	65410	180	15287	70	4098	33	3649	3454	92544	71
Wheat	23	12	299	13298	1316	0	37	12	1529	1543	18069	74
Beans	328	488	17242	1076	243070	1281	1190	220	17136	6939	288970	84
Sgr Bts	115	72	1081	221	6634	28122	184	27	507	197	37160	76
Forest	16518	1941	19226	143	9621	96	176105	1768	2364	5389	233171	76#
Water	20859	4328	2176	214	3032	32	8050	44676	732	3956	88055	51
Urban	25	0	736	758	1998	57	153	162	2643	2054	8586	31
Rangeland	978	634	2749	612	5802	203	3214	395	2800	9049	26436	34
Totals +	60680	13616	136831	16611	305048	30291	214623	52870	33794	37920	902284	67

GVD stands for Ground Verification Data. MIXED GR stands for mixed wetland grasses. SGR BTS stands for sugar beets. # and + the same as in Table 2.

habitat evaluation programs and assist in wildlife management (Lyon, 1983).

Continued work with the white-tailed deer computer based model is being conducted by the Corps' Detroit District and Waterways Experiment Station. Studies are being conducted to evaluate the performance of the Landsat TM data only and the TM data in conjunction with medium altitude aerial photography as habitat data variable sources for the computerized model. The objectives of these studies are to determine the relative performance levels of Landsat TM data separately and in combination with medium altitude aerial photography for white tailed deer habitat quality evaluations. The results of the work will facilitate an evaluation of cost versus performance for various levels of habitat data input and associated data collection techniques.

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