The Universal Transverse Mercator Code: A Location Code for Disease Reporting

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Abstract

Since November 1987, all rabies specimen reports submitted by Agriculture Canada's District Veterinary Officers have required a new location code, the Universal Transverse Mercator Code (UTMC). In addition to the previously required entries for county, district, legal address and mailing addresses, the new code is set up for computer analysis and mapping. It is capable of pinpointing the origin of the specimen to within 100 meters anywhere in Canada that is covered by the National Topographic System 1:50,000 maps. Because of its 100 meter spatial resolution, the code is of great interest to those studying the occurrence and spread of rabies. The code will also be important in the detailed planning and evaluation of the Ontario rabies control scheme, scheduled for 1988. Agriculture Canada anticipates that the UTMC will also be used for reporting other animal diseases as well as for emergency disease reporting.

Résumé

"Universal Transverse Mercator Code" : Un code de localisation pour les maladies nommées

Depuis novembre 1987, tous les échantillons soumis pour identification de la rage par les officiers vétérinaires du district d'Agriculture Canada ont nécessité un nouveau code de localisation : Universal Transverse Mercator Code (UTMC). Le nouveau code procure, en plus des informations habituelles telles le comté, le district et les adresses légales et postales, une analyse par ordinateur et une cartographie. Le code permet de localiser l'origine d'un échantillon dans un rayon de 100 mètres partout dans les régions du Canada desservies par le Système Topographique National (STN) 1:50,000 cartes. À cause de sa résolution spatiale de 100 mètres, le code devient un outil indispensable dans l'étude de l'apparition et de l'étendue de la rage. Le code sera aussi très utile dans la planification détaillée et l'évaluation du programme de contrôle de la rage en Ontario prévu pour 1988. Agriculture Canada prévoit que l'UTMC sera aussi utilisé pour rapporter d'autres maladies chez les animaux d'une part, ainsi qu'établir un système d'urgence d'autre part pour les maladies nommées.

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Introduction

In 1977, Agriculture Canada's (Ag Can) Health of Animals Division instituted a location code, the "nearest town" code, for the rabies specimen submission reports in an effort to increase the spatial resolution of rabies reporting. The code was a combination of numbers and letters indicating province, county, township, and nearest town within a township. Federal veterinarians were required to enter the code for the town nearest the positive rabies case on the submission form. A codebook of nearest towns was provided.

The "nearest town" code was an important step towards improving rabies reporting. Agriculture Canada, however, soon recognized problems with the code. In densely populated areas, towns are close together, whereas in rural areas towns are farther apart and thus the resolution of the code varied with human population density. The nearest town codebook, derived from a wide series of map bases, was difficult to update. Field veterinarians, frustrated at the discrepancies between the maps they were using in their field work and the codebook, resented hunting through the codebook for alternatives. The overall result was a lack of interest in completing the code at all and a high error rate in identifying the nearest town.

In 1985, the development of the new Laboratory Sample Control System (LSCS) for the computer tracking of laboratory submissions, coupled with the consequent redesign of the rabies specimen reporting form, provided Ag Can with a convenient opportunity to implement an improved location code. Two major decisions were made. First, the new code was to be based on a map grid. Grids are easy to use and produce constant resolution codes. Furthermore, grid-based data are easily aggregated to other scales and facilitate computer analysis. Second, the grid was to be based on the Universal Transverse Mercator (UTM) coordinate system which is rapidly becoming the standard for many provincial and federal agencies dealing with maps. Hence the disease data could be easily transferred to a variety of other maps and, if necessary correlated with other mapped data. Thus the Universal Transverse Mercator Code (UTMC), was born. The purpose of this paper is to describe the UTMC, explain why the system was adopted by Ag Can, and to point out how it can be used to enhance disease reporting and analysis.

The Universal Transverse Mercator Code

Agriculture Canada's UTMC is a location code based on the rectangular grid coordinate system inherent in the Universal Transverse Mercator projection which is the basis for Canada's National Topographic System (NTS) of maps (1). The UTMC is read from Canada's basic topographic maps, the NTS 1:50,000 sheets, and consists of 9 to 12 digits. The first three to six digits give the map sheet number and the next six digits give the grid reference coordinates. For example, the UTMC for the Parliament Buildings in Ottawa (Figure 1) is:

31G5 452 302

where 31G5 is the 1:50,000 map sheet number, 452 is

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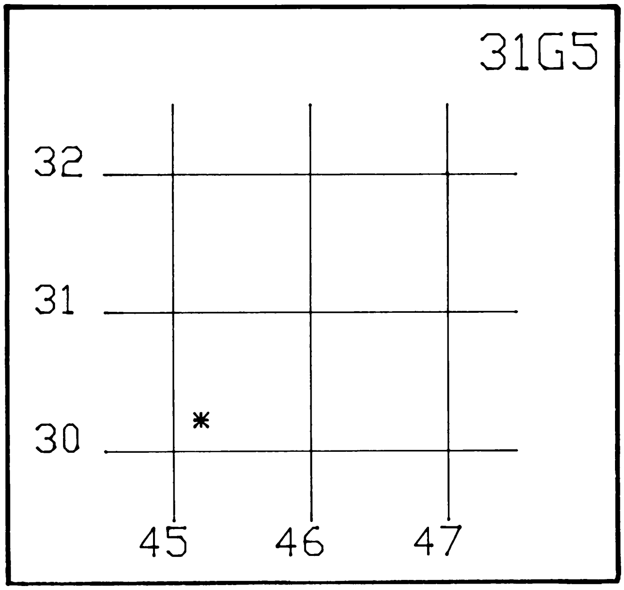

Figure 1. Location of the Parliament Buildings in Ottawa by UTM code.

the "easting" coordinate (X axis), and 302 is the "northings" coordinate (Y axis). The eastings and northings are read directly from a grid of labeled lines on the map that represent a spacing of 1 km (1000 meters). In Figure 1 for example, the "*" is located between the eastings grid lines 45 and 46. The location of the "*" between the two grid lines is estimated in tenths. Thus the correct easting for the "*", which is two-tenths of the way between 45 and 46, is 452 (45.2 km). Similarly, the northings location is estimated as 302 (30.2 km).

A map sheet number has three components. In the previous example, the "31" refers to quadrangle 31. The National Topographic System has divided Canada into numbered primary quadrangles which are indexed east to west by 8° zones of longitude and south to north by 4° zones of latitude. The primary quadrangles are mapped at the 1:1,000,000 scale.

The second component denotes a subdivision of the primary quadrangle into sixteenths (the 1:250,000 scale) with each such subdivision being assigned a letter from A through P south of 68° and A through H north of 68°. The final component is based on subdividing each 1:250,000 sheet by 16 to produce the 1:50,000 series which are assigned numbers from 1 to 16. Thus, in our example (31G5), the "G" refers to the 1:250,000 series and the "5" refers to a 1:50,000 sheet nested within the larger scale series.

The UTM projection solves the problem of showing the curved earth's surface on a flat map by dividing the globe into six degree strips of longitude, called zones, running south-north from 80 degrees south to 84 degrees north (Canada extends to 84 degrees north). The zones are numbered from the International Date Line, and Canada is covered by zone 7 on the Pacific coast to zone 22 on the Atlantic coast (Figure 2). Each zone is then mathematically flattened, a procedure that produces some distortion of geographical features, but since the zone is narrow the distortion is small enough to be ignored. This projection also produces a rectangular grid of lines from which the eastings and northings are read. That grid is unique to each zone and coordinates plotted

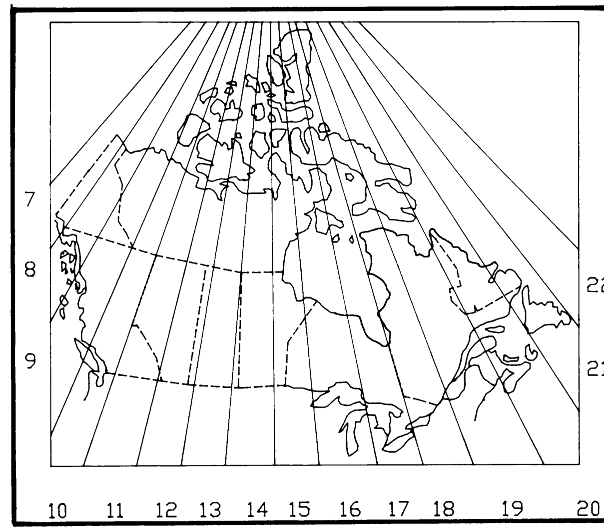

Figure 2. Universal Transverse Mercator zones in Canada.

within a zone must be translated and rotated to line up with coordinates in other zones if the user wishes to plot maps crossing zones (see the section on "Conversion").

The UTMC does not directly indicate the zone in which the case occurs. Since each map sheet fits uniquely with a zone, a "dictionary" matching map sheets to zones can be developed. Agriculture Canada could have used the military grid system of reporting UTM coordinates that is described on every NTS 1:50,000 map. That system indicates the zone number and provides two letters that identify the 100 km grid squares on the 1:50,000 maps (UTM coordinates repeat every 100 km and the grid square reference makes the coordinates unique). Thus the full military system reference for the Parliament Buildings is:

18T VF 452 302

where 18T is a zone identifier, VF is the two letter 100 km grid indentifier, and the 452 302 is the eastings/northings reference as before. Agriculture Canada preferred to use the map sheet number for three reasons: (i) the two grid reference letters are hard to find and read on the NTS maps (they are in light blue); (ii) emergency disease reporting is done on a map sheet basis, i.e. the field officer phones in the location on his/her map to be plotted on a similiar map at the disease control center; and (iii) the zone and grid numbers can be determined as necessary from the "dictionary" mentioned above.

Choice of Map Base

Agriculture Canada set five requirements of an appropriate map base for disease coding:

1. Canada-wide coverage at least cost
2. UTM grids are shown
3. The reporting scale is appropriate
4. User convenience at the District Office or field level
5. Standardization for reporting purposes at the national level.

All the requirements but number 4 are met by the National Topographic Series (NTS) of maps at either the 1:50,000 or 1:250,000 scales. An earlier field trial using the NTS 1:250,000 scale maps in Ontario had demonstrated the feasibility of using those maps (2). Since lot, township, and concession, however, are used to locate farms in Ontario, the Ontario Regional Office requested that maps be developed giving lot and concession and having the UTM grid. Before these maps could be developed for field use, a further change was requested. The emergency disease reporting unit asked that all provinces purchase NTS 1:50,000 scale maps. Rather than have two systems in use, Ag Can decided to develop a code using the 1:50,000 scale of maps for British Columbia, Ontario, Quebec and the Maritimes.

In the Prairie Provinces, Ag Can decided to continue using the legal land system of township and range that had been in place since the prairie land grants were first surveyed. That system originated from the Dominion Land Survey (DLS) which laid the prairies out in a regular north-south, east-west grid. The basic unit of the DLS was a township which is almost exactly a six-mile square (3). Each township was broken into 36 sections with each section one mile square and each section being further subdivided into quarters one half mile square. The townships were numbered in the north-south direction starting at one on the Canada-United States border and increasing by one every six miles to the north. The townships were identified in the east-west direction with range numbers starting sequentially east and west of six meridians (lines of longitude) and increasing by one every six miles. For example, a rabies case on the outskirts of Whitewood, Saskatchewan could have the location:

NW7 16 2 W2

which translates to the northwest quarter of section 7, township 16, range 2 west of the second meridian. The resolution of this code is 0.25 square miles or 0.64 square kilometers. Although the resolution of the UTMC is better, the resolution of the DLS system is quite acceptable given the relatively low settlement density on the prairies.

Conversion of UTMC for Mapping and Analysis

The UTMC will be used in two general ways (i) for emergency disease reporting, and (ii) for reporting disease statistics in map and tabular form. For the former application, the UTMC will be used "as is" since reporting consists of transferring locations from field maps to similar maps at the disease control center. For the latter application, composite maps and tables are required and the UTMC must be converted to a general X,Y coordinate system that is independent of map sheet boundaries. The following paragraphs describe that conversion process.

a) Conversion to x,y coordinates within a zone

Each 1:50,000 map sheet lies within a UTM zone. Hence it is possible to prepare a list of the coordinates of the lower left corner of each map sheet in a zone. Those coordinates are then added to the eastings and northings of the UTMC. Thus, in the previous example, (UTMC 31G5 452 302) the list of map sheet coordinates shows that the case is in zone 18 and that the lower left corner of sheet 31G5 has the value:

4230 50120

relative to the coordinate system for zone 18. Adding those values to the easting (452) and the northing (302) produces:

4682 50422

where the values are to the nearest tenth of a kilometer, i.e. 4682 is read ad 468.2 km and 50422 is read as 5042.2 km. In many cases, the UTM is expressed in meters, i.e. 468200 5042200 making a total of 13 digits. This easting is relative to the central meridian of the zone which is given the arbitary value of 500000 meters and the northing is distance north of the equator in meters.

The zone number and the coordinates of the lower left corner of the map sheet can also be read directly from the map. This is acceptable for a few cases but inconvenient for many. Since the NTS maps are numbered in a set order, the conversion can also be done with a computer algorithm that calculates the proper zone number and the corner coordinates.

Agriculture Canada has such a program (written in QBASIC) and will make it available to users of the LSCS data. Those users must transfer the raw UTMC data to their own computer and make the conversion using the Ag Can program. That decision was made to minimize the computational burden on the LSCS. This scheme also allows some flexibility in the UTMC system. For instance, metropolitan areas may require larger scale maps than the 1:50,000 sheets so that street names can be identified. Provided UTM based maps at other scales can be obtained, a modified version of the UTMC can be used for the problem areas. The computer program can be modified to recognize the modified codes and make the necessary conversions to Ag Can's standard UTMC.

b) Conversion to x,y coordinates across zones

The second step of the conversion is required only if the cases of interest occur in two or more adjacent UTM zones. Since the central meridians for adjacent zones converge towards the poles, the UTM grid from one zone cannot be extended directly into another. Thus the computer algorithm cited above also includes a routine for translating and rotating from one zone to another, i.e. the user chooses a "master" zone and all UTMC values in the other zones are recalculated in the coordinate system of the master zone.

c) Conversion of DLS codes to UTMC and x,y coordinates

Agriculture Canada has another conversion program to change township and range values from the DLS system in the prairies to UTMC. This program converts the prairie township/range codes to zone numbers and general x,y coordinates. The conversion routine in (b) above can then translate and rotate those values to x,y coordinates spanning zones. The DLS to UTMC algorithm will also convert DLS codes to latitude and longitude.

Discussion

Many alternatives were considered to replace the old Ag Can code. Since they were already present on the original rabies specimen reports, the postal code, the rural route number, and the legal survey address were candidates for a location code. Postal codes were rejected since the areas they represent vary in size from very large in low density rural areas to very small in high density urban areas. Rural route numbers were rejected because they also vary in size and can change at the discretion of the local postmaster. Legal surveys were tempting because of the success of the township and range system in the prairies. The survey systems in the other provinces, however, are not as regular as the Dominion Land Survey and require extensive manipulation to convert the survey information (e.g. township, concession and lot in Ontario) into usable coordinates. This was tried in Ontario but found lacking primarily because of the difficulties of treating misspellings, and the wide range of synonyms used for concession names (4).

Many of the considerations in designing the UTMC such as resolution, form, ease of use and relationship to emergency disease reporting have already been discussed. Nearly 9000 of 13,150 NTS 1:50,000 maps required to cover Canada are finished. Most of the unfinished sheets are north of the Arctic Circle which affects only a handful of rabies cases, e.g. there were only 16 reported rabies cases in that area in 1986. Since many of these areas are covered at the 1:250,000 scale, UTMC can be derived if necessary. Given that the 1:50,000 series shows more detail than the 1:250,000 series and is the basic series from which many other federal and provincial maps are derived, we decided to base the UTMC on the 1:50,000 scale.

During the development of the UTMC and the concurrent implementation of the Lab Sample Control System, the rabies submission form was redesigned to accept both the UTMC system and the Legal Land System coding to be entered by the field veterinarian. On the specimen's arrival at the laboratory, limited error checking for the UTMC occurs when the code is entered into Ag Can's Lab Sample Control System (LSCS). The checking is based on the premise that the district office code on the specimen report is correct. The LSCS contains a list of valid map sheets for every district office. It also contains a list of valid township and range identifiers for each prairie district office. Thus, if the system finds a mismatch between the UTMC and the district office, the error is flagged for checking. This system cannot check that the eastings and northings or the township and range are correct or entered in the correct order. It is hoped that by making the system simple and easy to use, error will be minimized.

What then are some of the applications of a coded location system in disease reporting? These grid-based data lend themselves to analysis once the UTM code is converted into a simple X,Y reference coordinate divorced of a map sheet identifier. Once this is accomplished, the simplest application is a tabulation of data. Conversion of the legal land system code into similar coordinates would allow the data to be presented as a national table. A more exciting presentation of the accumulated data would be a graphic output. This allows for a more visual mapping of rabies cases by area and species.

One question often asked by field staff is, "What do you need these data for?" If the field officer could see a graphic use of his/her cases as a feedback he/she would then more fully appreciate his/her effort which should lead to more careful reporting and fewer errors in reporting. A graphic representation of results is one of the main objectives of the coding.

The code lends itself not only to the reporting of rabies cases but of any disease occurrence one chooses to capture. Two Ag Can programs could use the coding right away. One is the occurrence of a foreign animal disease outbreak in an area and a reporting of diseased or quarantined areas. Reports of the disease could be presented graphically. The National Animal Health Information System (NAHIS) program is in its infancy, but, conceivably, swine premises could be coded to allow mapping of any health problems.

The second reason for developing a more accurate location coding system for rabies cases was its application to predicting outbreaks of rabies in endemic areas. The cooperative research of many agencies to develop a method of vaccinating wildlife against rabies has reached the point of moving from the laboratory to the field. Before a meaningful vaccination program can be carried out, a database of information on rabies cases in an area is needed. The coded disease data can be merged for analytical purposes with any of several other data sets (land use, topography) to develop a better understanding of the relationship between habitat and rabies at the micro level. Collected over a period of time, and plotted with trends of increased populations, rabies incidence in a specific area and contiguous areas could lead to the prediction of rabies in that region and a resulting action of vaccine baits dropped into the area to inoculate a susceptible population.

A secondary application of the code in the baiting of an area is to monitor the impact of bait placement. Monitoring of antibody levels of wildlife in a bait drop area through blood samples taken from road kills, shot and trapped animals and specimens sent for rabies diagnosis will give an indication of the ratio of protected to nonprotected animals. This nonprotected population will be a result of incursions from contiguous areas by nonvaccinated animals, new progeny within the baited population, animals that did not pick up the bait or animals which are (for some reason) immunologically incompetent. At some point, the monitoring of the ratio of protected to nonprotected animals and incidence of rabies in adjacent areas, will indicate that it is necessary to revaccinate animals to protect the younger population. Through constant monitoring and vaccination it may be possible to push rabies incidence to very low levels or eradicate the disease completely.

Another exciting use of the code is in the sharing of information. The Centre for Disease Control, Atlanta, has followed the lead of Agriculture Canada in the use of the UTM code for recording rabies within states of the USA. They, too, have considered the UTM code for recording diseases other than rabies. By ensuring that both countries are using similar coding standards, transfer of information can occur for the production of graphic data on North American rabies. This transfer will include Canada, the United States, and possibly Mexico. As the system is extended to other countries, transfer could then occur at many levels. The transfer has another spin-off. Wildlife rabies knows no boundaries. With accurate, up-to-date information on rabies, it would be possible to coordinate a cooperative effort to release baits on both sides of the border and monitor impacts.

This paper has emphasized the application of the UTMC for rabies reporting. We feel, however, that its simplicity, ease of use and resolution will make it appropriate for reporting other animal diseases. Simplicity and ease of use will also minimize error and encourage its adoption by other countries with similar mapping systems and computer systems. As well, in the future, data entry can be done at local terminals and more elaborate error checking routines can be employed. Local entry and analysis, particularly graphic representation, will encourage careful data entry and minimize errors.

Acknowledgments

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