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THE WORLD LANDSLIDE INVENTORY

Abstract: The International Geotechnical Societies' UNESCO Working Party on World Landslide Inventory has been formed from the International Association for Engineering Geology's Commission on Landslides, the International Society for Soil Mechanics and Foundation Engineering's Technical Committee on Landslides and representatives of the International Society of Rock Mechanics to establish a World Inventory of Historic Landslides. The Inventory, a contribution to the International Decade for Natural Disaster Reduction would assist United Nations agencies in understanding the world distribution of landslides.
The Working Party has prepared a Suggested Method for Reporting a Landslide and drafted a Suggested Method for a Landslide Summary. These methods allow the creation of uniform, computer-processible banks of landslide data. A survey of existing landslide inventories reveals considerable potential for improvements with existing microcomputer-based technology. Landslide inventories provide the fundamental information necessary for sound risk management or landslide insurance schemes. Their information on landslide dimensions allows the construction of volume-frequency curves for estimating total sediment production, for the prediction of hazards from landslide runout and of the encroachment of landslides on uplands. The successive occurrences of landslides in an area may form a pattern, allowing more precise prediction of sites liable to move in the future. Annual and longer term patterns of landsliding may give advance warnings of times of high landslide hazard and suggest likely responses to climatic changes.

INTRODUCTION

A Working Party of the International Association for Engineering Geology Commission on Landslides and Other Mass Movements, the International Society for Rock Mechanics and the International Society for Soil Mechanics and Foundation Engineering Technical Committee on Landslides has been formed to assist the establishment of a World Inventory of Historic Landslides. The

Inventory is a contribution to the International Decade for Natural Disaster Reduction. In recognition of the assistance of UNESCO, the Working Party has adopted the title "International Geotechnical Societies' UNESCO Working Party on World Landslide Inventory" (abbrieviated to WP/WLI). The Working Party has prepared a Suggested Method for the compilation of the basic unit of the Inventory, the Landslide Report (12).

Working Groups have been set up by the Working Party to suggest methods of classifying the rates of movement of landslides, their causes, their geology, their activity and the distribution of movement within landslides. Another Working Group has drafted a Suggested Method for the compilation of landslide information as a Landslide Summary.

STRUCTURE OF THE WORLD INVENTORY

The Landslide Report is the building block of the World Landslide Inventory. The Suggested Method proposes standard measures to be used in reporting historic landslides. Numeric information from the Report can be compiled using a database management program into the Landslide Record which will be a summary of the information provided by the Report. A cumulative bibliography, compiled in a separate file, can be updated with additional references as they appear in the Landslide Reports. The information on landslides provided by these Reports can then be assembled and made available to local, national and international authorities.

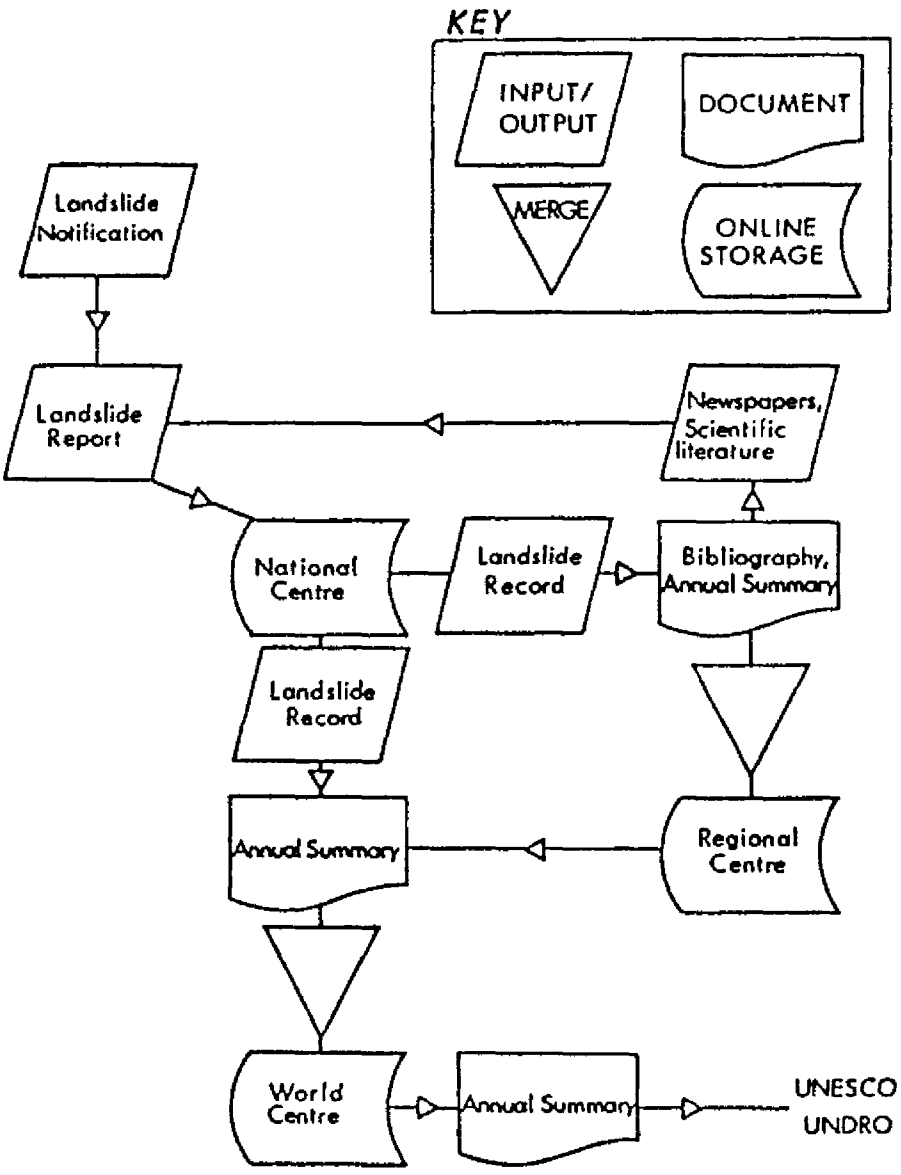
The conceptual information flow for the World Landslide Inventory illustrates the passage of landslide information from notification to its place in the World Landslide Inventory (Figure 1). Once a significant landslide has occurred, the agency for local landslide inventory is notified and the Landslide Report is professionally completed. This Report is then numbered and translated into a Landslide Record at the national level. At the same time, any references to the landslide are added to a national bibliography established in a separate database file. The Landslide Record is then added to the National Inventory. The Records in this inventory are compiled annually to produce a national Landslide Summary. This Summary is then sent in computer-processible form to the World Centre where landslide summaries from different countries are assembled to create and sustain the World Landslide Inventory. This information can then be made available to engineers, geologists, planners and other interested persons.

To summarize, the Landslide Report leads to the Landslide Record, which leads to the Landslide Summary, transferring information from the local to national centres, and thence to the World Centre. All three components provide the foundation on which the World Landslide Inventory is based.

THE LANDSLIDE REPORT

The Landslide Report, a suggested method of reporting landslides, provides a permanent record of details that cannot be coded in the database Record. Because of the need to code the data, complex descriptive details which may face language barriers are avoided. The Report establishes minimum data requirements while

FIGURE 1
CONCEPTUAL INFORMATION FLOW FOR THE
WORLD LANDSLIDE INVENTORY



permitting additional, detailed observations in the 'comments' section (Figures 2, 3). The Report uses terminology from Varnes (11) and the IAEG Commission on Landslides and Other Mass Movements (7).

Because it is not practical to report all landslides, the Working Party proposed that a significant landslide satisfied at least one of the following criteria:

1. is over 1 million cubic metres in volume
2. causes casualties
3. causes considerable direct or indirect damage.

As the Inventory is concerned with historic landslides, only those that can be dated to at least the nearest year should be recorded.

The Landslide Report is arranged to permit ready coding for computer processing. Consequently, observations are either numeric or mutually exclusive categories that can be classified numerically. Each category is represented by a number so that information is transcribable to the electronic database.

References in the Report and descriptive comments are not transferred to the Landslide Record. A separate file of references is however created and represented by accession numbers in the Record. The comments need not be transferred to the Record but should remain on file with the Landslide Report. Landslide Reports should be maintained in National Centres for public reference.

The Working Party's Suggested Method (12) has given detailed specifications for the measurement of the position, date, type, geometry, volume and damage of an individual landslide.

THE LANDSLIDE RECORD

The Landslide Record (Figure 4) summarizes the information provided by the Landslide Report. The annual compilation of these Records constitutes the Landslide Summary. As the information is transferred from the Landslide Report to the Record, several changes are made. Some information, the Date of Report, the Landslide Locality, the details about the reporter and the Comments in the Landslide Report is not entered in the Landslide Record. This information as well as information on the volume calculation (the formula applied and the swell factor) can be accessed from the Report, as the need arises.

Two fields, the Numeric Code for Country and the National Inventory Number, are additions to the Landslide Report necessary to complete the Landslide Record. The Numeric Code for Country, obtained from the United Nations' List of Country Codes, identifies the country in which the landslide occurred. The National Inventory Number will identify the landslide in that country. Combined, the Country Code and the National Inventory Number will represent the landslide in the World Landslide Inventory.

The Damage entry in the Landslide Summary differs from that in the Report. When documenting the landslide in the Landslide Report, the damage value should be an estimate of the economic damage caused by the landslide, given in the local currency. For the Landslide Summary, this damage estimate is then converted by division by the per capita GDP into a damage value in 'person-years'. GDP, or Gross Domestic Product, is an economic measure of total expenditures

FIGURE 2
A LANDSLIDE REPORT - SIDE 1

LANDSLIDE REPORT

Date of Report (day mo. yr.) 17 / 9 / 89 /

Landslide Locality St Jean Vianney National Inventory Number 1

Reporter: Name T de Lugt

Affiliation University of Alberta

Address Department of Geology
University of Alberta
Edmonton Alberta
T6G 2H1

Phone (403) 492-5798

Position: Latitude (degrees minutes seconds) 48 ° 28 ' 40 " hemisphere N

Longitude 71 ° 13 ' 00 " hemisphere W

Elevation: crown 72 m a.s.l.

rupture surface toe - m a.s.l.

tip 38 m a.s.l.

Date of occurrence: (day mo. yr.) 4 / 5 / 71 /

Type: First movement (circle the appropriate numbers and terms)

1. rock 2. debris (3. earth)

1. fall 2. topple (3. slide) 4. lateral spread 5. flow

Second movement (circle the appropriate numbers and terms)

1. rock 2. debris (3. earth)

1. fall 2. topple 3. slide 4. lateral spread (5. flow)

FIGURE 3
A LANDSLIDE REPORT - SIDE 2

Geometry: Rupture Surface Displaced Mass

Length L_r = 762 m L_d = 2,126 m L = 2,880 m

Width W_r = 518 m W_d = 518 m

Depth D_r = 23 m D_d = 10 m

Volume: $V = \pi L_d D_d W_d / 6$ or V = Swell factor =

$V = 6.9 \text{ m}^3 \times 10^n$ n = 6

Damage: Value 17 M Currency Cdn $

Injuries — Deaths 31

References:

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2. Tavenas, F., Chagnon, J.-Y. La Rochelle, P., 1971. The Saint-Jean-Vianney Landslide: Observations and Eyewitnesses Accounts. Canadian Geotechnical Journal, 8: 463-478.

3. Ministère Des Richesses Naturelles, 1974. Rapport de Synthèse des Études de la Coulée D'Argile de Saint-Jean-Vianney. Gouvernement du Québec, Québec.

Comments: The Report is based on the references above.

FIGURE 4
THE LANDSLIDE RECORD, A LINE IN THE LANDSLIDE SUMMARY

Field Column	Field Description	Field	Width
1-3	Numeric code for country	1	3
4-8	National Inventory number	2	5
9-10	Position, Latitude, degrees	3	2
11-12	minutes	4	2
13-14	seconds	5	2
15	hemisphere	6	1
16-18	Longitude, degrees	7	3
19-20	minutes	8	2
21-22	seconds	9	2
23	hemisphere	10	1
24-26	Elevation, crown (m a.s.l.)	11	3
27-29	rupture toe (m a.s.l.)	12	3
30-32	tip (m a.s.l.)	13	3
33-36	Date, year	14	4
37-38	month	15	2
39-40	day	16	2
41	Type, first movement, material (1-3)	17	1
42	type (1-5)	18	1
43	second movement, material (1-3)	19	1
44	type (1-5)	20	1
45-48	Geometry, Length, L_r (m)	21	4
49-52	L_d (m)	22	4
53-56	L (m)	23	4
57-59	Width, W_r (m)	24	3
60-62	W_d (m)	25	3
63-64	Depth, D_r (m)	26	2
65-66	D_d (m)	27	2
67-69	Volume, in cubic metres x 10^n	28	3
70	n, order of magnitude	29	1
71-75	Damage, value in person years	30	5
76-78	injuries	31	3
79-81	deaths	32	3
82-86	References, 1	33	5
87-91	2	34	5
92-96	3	35	5
			96

and the total value of goods and services produced in a nation during a specific period, excluding net property income from abroad. The GDP is divided by the population to produce the person-product, the average contribution per person to the GDP for that year. This value, divided into the damage estimate produces a damage value in person-years, or the number of years of production it will take inhabitants of that country to repair the damage caused by the landslide. .

Population data can be found in Demographic Yearbooks published by the United Nations. Gross Domestic Products are listed in the Statistical Yearbooks, also published by the United Nations, and in the World Development Reports published by the World Bank. Local, authoritative sources of statistics can also be used. For instance, the Canada Yearbook, published by Statistics Canada, provides annual estimates of GDP and population.

The Landslide Summary will also have a record of the total number of deaths and substantial injuries, as given in the Landslide Report.

To illustrate the proposed method of damage assessment, consider the St. Jean Vianney landslide, Quebec, Canada (Figures 2, 3). This landslide occurred on May 4, 1971, and involved an area of about 268,000 m^2. The damage cost, including relocating the local population, was established at $ 17 M. Forty-three houses were destroyed and 31 lives were lost (2). Population and GDP statistics for 1971 (Statistics Canada) allow the total economic damage to be calculated as:

$$\text{person-product (1971): } \frac{\text{GDP}}{\text{population}} = \frac{\$\ 97{,}290\ \text{M}}{21{,}568{,}300\ \text{people}} = \$\ 4{,}511\ \text{(person-product)} \qquad (1)$$

$$\text{person-years: } \frac{\text{damage estimate}}{\text{person-product}} = \frac{\$\ 17{,}000{,}000}{\$\ 4{,}511} = 3{,}769\ \text{person-years} \qquad (2)$$

3,769 person-years production are needed to repair the damage.

So, the total economic damage caused by the St. Jean Vianney landslide, using this culture- and currency-independent method, is calculated to be 3,769 person-years. The value of the damage in 1985 dollars is
3,769 x 19,025 = $72 M.

SOFTWARE

We have used PC-FILE, Version 5.0, as an inexpensive example of the software programs that can manage the landslide database. It is a general purpose database managment program that is powerful and easy to use. Its files are compatible with PC-FILE:dB, dBASEIII PLUS and other dBASE programs,

dBASE files can be read and edited by PC-FILE directly and PC-FILE databases can be processed directly by dBASE. Because of the popularity of dBASE as a database management program, the scope of PC-FILE is greatly increased. For the exchange of information however, the number of fields and the field lengths of the two databases have to be the same.

PC-FILE can also exchange data with other programs such as WordPerfect, Microsoft Word, Microsoft Excel, Lotus 1-2-3, PC-Calc+ and others. In most cases however, the database that is to be transferred should match the existing file exactly. The database should be defined as having the same number of fields with matching field lengths, and in the same sequence as the existing database. In general, PC-FILE stores, sorts, and retrieves data. Information is stored in the given format and can be modified as necessary. Data are organized either alphabetically, by date, or numerically. Also, PC-FILE prints reports, or lists according to specifications.

PC-FILE can run on the IBM series of personal computers or highly compatible computers. PC-FILE requires a minimum of 1 megabyte of available disk storage 512 K available RAM, a 80 column display, and DOS version 2.0 or later.

AN EXAMPLE

At the National and World Centres, analysis of the landslide data can provide valuable information on the occurrence of landslides. Mapping software can be used in conjunction with the landslide database to depict the distribution of landslides. Depending on the scale, maps can be used to indicate local, national, or global patterns of landslide activity.

The data can also be sorted to identify trends. For instance, if landslides are sorted by their month of occurrence, seasonal patterns may become apparent. If the data are sorted by year of occurrence, longer term patterns may be identified.

As a convenient small sample for demonstration purposes, a part of the Canadian Landslide Inventory, the historic landslides of Alberta, has been compiled in the PC-FILE database management program (3).

A variety of graphs such as line and dot graphs, bar charts (vertical and horizontal), pie graphs, regression lines and logarithmic plots can be produced. Two graphs were produced as examples (Figures 5 and 6). The first graph, a dot graph, depicts Albertan landslides over a ninety year period. To produce this graph, a database was formed to record the number of landslides that occurred each year since 1900. The resulting graph illustrates the temporal distribution of landslide activity in Alberta. Although the historic distribution of landslides is largely dependent on the reliability of the reporting process, there is an apparent increase in slope instability in the early 1970s.

The database for the second graph (Figure 6) was formatted with each option of material and movement types as a separate field, with one field being marked for each landslide entry. The resulting pie charts illustrate the type of movement, and the material involved in the primary and secondary components of

FIGURE 5
THE HISTORIC RECORD OF LANDSLIDING IN ALBERTA

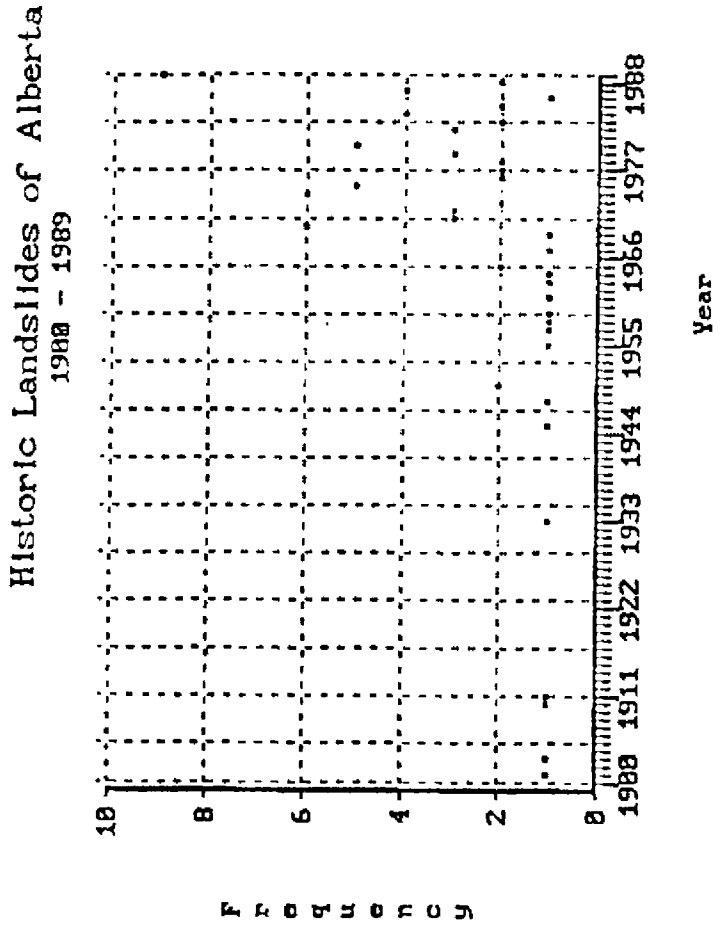
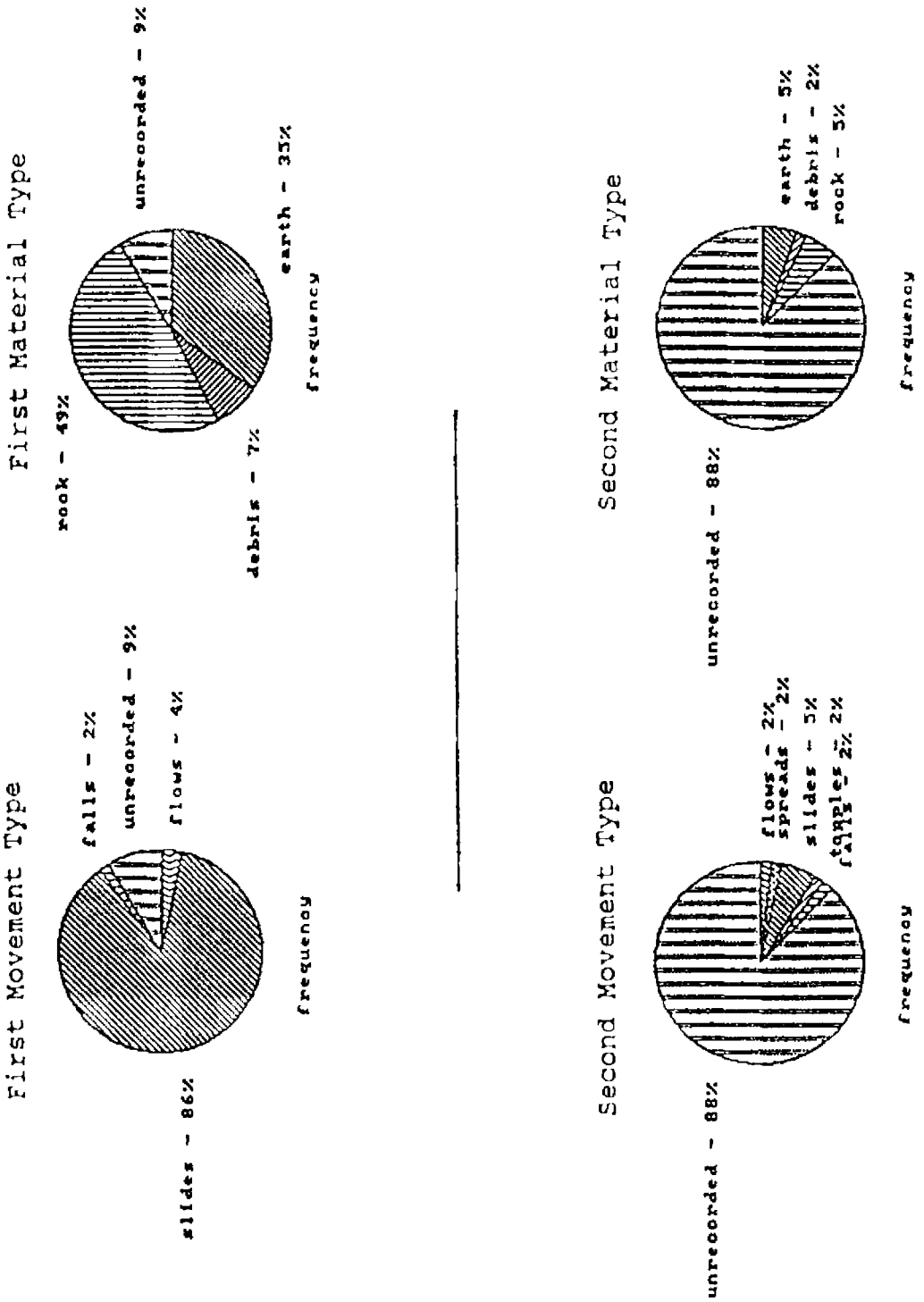


FIGURE 6
TYPES OF LANDSLIDES IN ALBERTA



landslides which have occurred in Alberta between 1900 and 1989. Apparently, most of the cases of slope instability in Alberta are slides in rock. Subsequent analysis of these and other trends might then indicate correlations between the occurrence of landslides and other factors.

DISCUSSION

The need to establish a World Inventory of Historic Landslides is apparent. The world distribution of landslides has not yet been mapped. Landslide studies are isolated, limiting their interpretation to local factors. Analyzing the occurrence of groups of landslides may reveal broad scale or interactive processes that contribute to movements. There is an obvious analogy to be drawn with the study of earthquakes.

Records of loss and damage by landslides are fundamental information necessary for sound risk management or landslide insurance schemes (5). Landslide dimensions allow the construction of volume-frequency curves required for the prediction of hazards from landslide runout (6, Figure 2) and encroachment by landslides on uplands (4). The relative dimensions of landslides can also be used to refine their classification and to predict forms and positions of their rupture surfaces when only the types of movement and displaced material are obvious (10). The successive positions of landsliding in an area can lead to the identification of waves of aggression and more precise prediction of sites liable to move in the future (8). Annual and longer term patterns of landsliding give advance warnings of when landslides may occur (9, 1).

The suggested method for reporting landslides, the Landslide Report, should simplify acquiring and accumulating information. Because the task of studying and reporting all significant landslides is immense, the Report requires a minimum of observations. These data, when transcribed to the Record and compiled at the National, Regional and World Centres will provide the basis for subsequent analyses. Once the Inventory is in place, the databank will provide information that will help to establish world patterns of landslide occurrence. This in turn will lead to a better understanding of the causes of landslides and to more accurate hazard assessments. Thus, the World Landslide Inventory will eventually lead to better predictive models, which can then be used to alleviate landslide risk.

The structure of the Inventory and the formats of the Report, Record and Summary are suggestions which can be modified by discussions from within and without the Joint Working Party. The Working Party (listed in (12)) welcomes carefully documented proposals for additions or amendments to the Suggested Methods.

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