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A universal size classification system for landslides

Abstract Size is a fundamental property of landslides, but it is described inconsistently within the scientific literature. There is currently no widely adopted size classification system applicable to all landslide types. A Scopus database search shows the most used landslide size descriptor is the term *large*, used to refer to landslides with volumes spanning ten orders of magnitude. Some size descriptors are unintuitive or potentially misleading (e.g. the term *massive* which describes a material property). We argue that a formal size classification scheme would encourage more consistent and logical usage of size descriptors and improve landslide science communication. To that end, we propose a size classification scheme suitable for all landslide types. The scheme provides a log scale of size classes for volume and area, with base units of cubic metre and square metre, respectively. In theory, there is no limit to the number of size classes possible. Six size descriptors are suggested, each spanning 3 orders of magnitude: very small (10^{-3}–10^{0} m^3), small (10–10^3 m^3), medium (10^3–10^6 m^3), large (10^6–10^9 m^3), giant (10^9–10^{12} m^3), and monster (10^{12}–10^{15} m^3). Our system does not replace existing (or preclude future) classification systems for specific landslide types (e.g. snow avalanche) that use numerical size classes, and it maintains consistency with some commonly used descriptors. Whatever system is used, we encourage people to define the terms they use and to quantify size where possible, so that clearer meaning is given to the words used to describe landslide sizes.

Keywords Mass movement · Magnitude · Science communication · Landslide area · Landslide volume

Introduction

Landslide size matters greatly, but there is no widely adopted standard for describing landslide size. This contrasts with several other landslide characteristics such as movement style and velocity for which standard terms and classifications exist (Hungr et al. 2014). As we will show from a review of existing usage of landslide size descriptors found in the scientific literature, no existing size classifications are adequately inclusive, and none are widely adopted or applied consistently. This could cause confusion or miscommunication about landslide hazard and impact, both within and outside of the scientific literature (e.g. by the media). We argue that a standard landslide size classification would be useful scientifically to help understand and communicate landslide hazard and impact. In this technical note, we elaborate upon these arguments and propose and explain a universal landslide size classification system, with the aim to encourage more consistent communication of landslide size information.

An argument for consistent landslide size description

We suggest that, for almost all uses of landslide information and for all landslide types, size is a fundamental property. The amount of material involved in a mass movement event influences its behaviour and motion and its physical and socio-economic impacts because larger landslides have a greater footprint. There is a well-observed positive correlation between volume and travel distance for all landslide types (Corominas 1996). Size also presents practical limits to the geotechnical works able to be implemented to mitigate landslides, with larger landslides often being more difficult and more expensive to mitigate (Bowman 2015). As landscape modifying agents, larger landslides tend to exert more geomorphic work, causing deeper erosion and imprinting more on topography (Korup 2005, 2008). Larger landslides can block rivers more effectively than their smaller counterparts, with greater knock-on effects in terms of cascading hazards (e.g. landslide-dammed lake outbursts) and interruption to fluvial sediment transport (Fan et al. 2020). Different landslide styles or failure mechanisms are typified by different-sized events (Hungr et al. 2014); for example, block toppling tends to produce smaller mass movements than deep-seated gravitational slope deformations. Rockfalls have (somewhat arbitrarily and perhaps without a clear process basis) been differentiated from rock avalanches based on size, for example, with rock avalanches exceeding 10,000 m^3 (Hungr et al. 2001) but more typically 1 million m^3 (Dufresne and Dunning 2017). Furthermore, landslide size can be linked to the environments and causes of failure. The largest terrestrial failures are mostly associated with volcanic edifice collapse, while the largest failures on Earth are submarine landslides. Topography exerts a limit on landslide size (Medwedeff et al. 2020); slope failure geometry scales with slope relief. On the other hand, many landslides in the upper tail of landslide size distributions are structurally controlled and/or thought to be triggered by strong earthquake shaking. As an example of structural control, the pervasiveness of extremely weak clay layers in gently tilted sedimentary rocks facilitates landslides that can be tens of square kilometres in area (Williams et al. 2021). Shallow, soil-stripping landslides on the other hand are limited in size by the thickness of soils or regolith. Finally, frequency-magnitude relationships universally show a decrease in landslides of increasing size (notwithstanding the rollover point common to many such power law distributions, below which ever smaller landslides (apparently or really) become less frequent; Tanyaş et al. 2019). For the purpose of debris flow hazard evaluation, Jakob (2005) argued that a size classification system was important because magnitude is a necessary element of hazard quantification, which we would suggest actually applies to all landslide types. Together, frequency and magnitude are the basis for landslide hazard and risk assessments (Glade and Crozier 2005) and so landslide size is clearly important to quantify and communicate clearly and consistently. Furthermore, frequency-magnitude relationships can be used to guide one's attention and priorities; Bowman (2015) suggested that due to their high frequency, small landslides (defined therein as having an event size of less than 1 km^2) are of greatest concern from a hazards and engineering point of view.

Consequently, size matters greatly in the world of landslides and should be a basic requirement for a complete landslide classification. While some size classifications have been attempted, as discussed next, they tend to be of restricted usage (e.g. for debris flows only or relevant to a restricted size range) or not widely taken up. Jakob (2005) surmised that size classifications have been rarely used because they are considered to provide little useful information relative to other, morphologic, or process characteristics of a landslide generally considered of greater importance. As argued above, size is important and a widely used size classification would be valuable, but presently, there is no standard for describing landslide size (Cornforth 2005, Huang et al. 2018) and the most widely used landslide classification scheme, that of Hungr et al. (2014) and its predecessors (Cruden and Varnes 1996, Varnes 1978), does not include guidance on size descriptions and size classes. On the other hand, a guideline on velocity classes and their descriptors has been available for some decades (WP/WLI 1995), and this was subsequently incorporated into the classification scheme of Hungr et al. (2014). There is no comprehensive guideline on how sizes should be communicated using simple descriptors such as *large*, *giant*, or *catastrophic* and, as we will show, size descriptors are used inconsistently in the scientific literature and are likely to be even more inconsistent in media, policy documents, and other public communications.

Existing size classifications

Several attempts have been made to define size descriptors or to establish size classifications (Table 1), but most have been developed for specific regions, usage, or landslide types. Fell (1994) presented a 7-class size classification for generic mass movement types, for helping to define landslide hazard, but the class boundaries (for volume) are somewhat arbitrary, and the largest class *extremely large* does not differentiate landslides with volumes greater than 5 M m^3. Hancox et al. (2002) presented a size classification for earthquake-triggered landslides in New Zealand. This provided more systematic (even) boundaries between classes than those of Fell (1994), and their largest descriptor (50 M m^3), also termed *extremely large*, is an order of magnitude larger than Fell's *extremely large* class. While perhaps appropriate for the contexts in which they were developed, the use of the term *extremely* (implying the end of a spectrum) by Hancox et al. (2002) and Fell (1994) limits wider applicability. The magnitudes for which they apply the term *extremely* are not *extreme* when considering the upper tail of landslide size distributions globally or beyond. For example, the volume of the submarine Storegga Slide has been estimated to be a minimum of 2400 km^3 (Haflidason et al. 2004), and the largest known failure on Mars is the 10^6 km^3 Olympus Mons rock avalanche (Crosta et al. 2018), both many orders of magnitude larger than the *extreme* class of Hancox et al. (2002) or Fell (1994). Subsequently, Hancox and Perrin (2009) introduced an additional size class, *giant*, to represent landslides greater than 10^8 m^3 in volume, but they continue to use the adverb *extremely* for the next size class down (landslide volumes of 10^7–10^8 m^3). While most size classifications are based on landslide volume, Cornforth (2005) suggested a 6-class size classification for landslide area, starting from < 200 m^2 for *very small* and increasing by one order of magnitude for each subsequent class, until their *huge* class (> 2,000,000 m^2). Others have avoided assigning multiple classes and instead preferred binary classification or have distinguished a size range for particular types of landslides. Bowman (2015) suggests that *small* landslides are those landslides smaller than 1 km^2 in area, while several studies have defined *large* landslides to have a volume greater than 10^6 m^3 (Huang et al. 2018). Evans et al. (2006) suggested that *massive* rock slope failures involve volumes from 10^5 to 10^{10} m^3. Others have developed size classifications for specific mass movement types, for example, debris flow (Jakob 2005) or snow avalanche (McClung and Schaerer 1980), and both of these examples have favoured use of numerical size classes (e.g. class 1) over descriptive classes (e.g. small). The European Avalanche Warning Service (EAWS) uses both numerical and descriptive size classes for snow avalanches (European Avalanche Warning Service, 2021). As we will see in the next section, none of these terms or classifications are widely or consistently utilised, even for snow avalanches—as pointed out by Moner et al. (2013)—for which size classifications are comparatively well established.

A review of existing size descriptor usage

Method

Before presenting suggestions for a more consistent use of size description and classification, we undertook a review of existing size descriptors in the scientific literature. Different measures of landslide size exist, such as area, volume, travel angle (Fahrböschung), runout distance, or potential energy, but we limited our review to volume and area size descriptors. Volume is a common measure of size and is arguably the most important due to its strong influence on runout and landslide impact, but because area is more easily measured, we included this as well. To evaluate existing usage of landslide size descriptors, we used the Scopus search engine to search literature that used size descriptors (a search prefix) in association with (i.e. joined using the Boolean operator AND) a range of mass movement synonyms or types (a search suffix). We chose 16 size descriptors (prefixes) which we considered likely to have been used. While we may have missed other descriptors, the purpose of this exercise was to assess consistency in the use of size descriptors generally, rather than to evaluate all descriptors in usage. We searched for these terms in the titles, abstract, and keywords of literature prior to the year 2020 (Table 2). The total number of hits (i.e. search results) was recorded for each descriptor.

The articles were then sorted using the *relevance* sorting tool in Scopus, from which we selected the first 100 articles for each size descriptor search result. Each article was downloaded or viewed online, to extract the quantitative size information for the particular size descriptor from within the main text. If an article was not accessible from Scopus (via the authors' institutional accesses), an attempt was made to source a freely available copy through other sources (e.g. Google Scholar or ResearchGate), but for some, it was not possible to secure a copy.

For some search results, the quantitative size information provided was a measurement of one or more individual landslides; if multiple landslides, we took the smallest and the largest values for that size descriptor. In other papers, the size descriptor was defined by the author (e.g. "herein we define large as > 1 M m^3"), in which case we treated the definition as a minimum value unless otherwise stated. If a size descriptor (e.g. large) was used but no definition or quantitative information was provided, we made a note of this. Search results were discarded if the literature was

Table 1 Examples of existing generic and type-specific landslide classifications

Generic classifications						
Author	Fell (1994)		Hancox et al. (2002) and Hancox and Perrin (2009)		Cornforth (2005)	
Application	Risk assessment		Earthquake-triggered, New Zealand		Generic	
	Descriptor	Quantity (vol., m^3)	Descriptor	Quantity (vol., m^3)	Descriptor	Quantity (area, m^2)
	Extremely small	$< 5 \times 10^2$				
	Very small	5×10^2–$< 5 \times 10^3$	Very small	$< 10^3$	Very small	$< 2 \times 10^2$
	Small	5×10^3–5×10^4	Small	10^3–10^4	Small	2×10^2–2×10^3
	Medium	5×10^4–2.5×10^5	Moderate	10^4–10^5	Medium	2×10^3–2×10^4
	Medium-large	2.5×10^5–1×10^6	Large	10^5–10^6	Large	2×10^4–2×10^5
	Very large	1×10^6–5×10^6	Very large	10^6–50×10^6	Very large	2×10^5–2×10^6
	Extremely large	$> 5 \times 10^6$	Extremely large	$> 50 \times 10^6$	Huge	$> 2 \times 10^6$
Type-specific classifications						
Author	Jakob (2005)		McClung and Schaerer (1980)		European Avalanche Warning Service (2021)	
Application	Debris flow		Snow avalanche		Snow avalanche	
	Numerical class	Quantity (vol., m^3)	Numerical class	Quantity (mass, *t*/length, m)	Numerical class and descriptor	Quantity (vol., m^3/length, m)
	1	$< 10^2$	1	< 10/10	1, small	10–30/100
	2	10^2–10^3	2	10^2/100	2, medium	50–200/1000
	3	10^3–10^4	3	10^3/1000	3, large	several 100/10,000
	4	10^4–10^5	4	10^4/2000	4, very large	1000–2000 /100,000
	5	10^5–10^6	5	10^5/3000	5, extremely large	> 2000/> 100,000
	6	10^6–10^7				
	7	10^7–10^8				
	8	10^8–10^9				
	9	10^9–10^{10}				
	10	$> 10^{10}$				

irrelevant (e.g. avalanching in grain silo computer simulations), not written in English, or inaccessible. For one size descriptor, *giant*, we compared the 100 most relevant results with all results, to assess whether choosing only the first 100 search results made a notable difference (which it did not). To visualise the results, the ggplot2 package (Wickham 2016) was used in RStudio to produce plots of landslide size class usage for volume and area. The same package was used to produce a frequency histogram of landslide volumes to assess which size landslides were most frequently referred to in the literature sampled.

Table 2 Landslide size descriptor search prefixes with lists of the mass movement terminology search suffixes used in the Scopus database, up until 2020. The Scopus search function "PRE/1" was used ahead of the suffix (permitting for example "small shallow landslide")

Size descriptors (prefixes)	Mass movement terminology (suffixes)
Gigantic, giant, mega, huge, massive, "extremely big", "very big", big, "extremely large", "super large", "very large", large, medium, small, "very small", tiny	"mass movement" OR "slope failure" OR landslide OR "debris flow" OR "submarine landslide" OR "avalanche" OR "rock fall" OR DSGSD OR topple OR sturzstrom OR slide OR "palaeo landslide" OR "paleo landslide"

Results

The search results revealed wide usage (thousands of hits) for the *large*-size descriptor, moderate usage (hundreds of hits) for several descriptors (e.g. giant, small, massive, huge), and few hits (fewer than 100) for all other descriptors searched (Table 3). After sorting by relevance and selecting up to the first 100 hits for each descriptor, 35% of the total hits returned (for all size descriptors) contained a quantitative measure of size (Table 3). More than a fifth of the hits made use of a size descriptor but without explaining its quantitative meaning. The remainder (43%) were either irrelevant, not written in English, or otherwise inaccessible.

The size data extracted from the first 100 samples for each descriptor show that landslide size descriptors are used inconsistently. Most size descriptors span several orders of magnitude. Usage of the *large* descriptor for landslide volumes spans almost 10 orders of magnitude, being used to describe landslides from less than 10^4 up to 10^{13} m^3 in volume (Fig. 1). Even for studies that defined the term large (Fig. 2), there is a wide range in volumes, with some defining large as being over 10^3 m^3 while others define it as over 10^{11} m^3 (Fig. 2). Likewise, for *giant* the definitions range from 10^6 to over 10^{13} m^3 (Fig. 2). For some terms for which there is a clear size order implicit in the names (e.g. *mega*), the quantitative data did not conform to this. The mean value for *extremely big* was smaller than *big* and, likewise, the mean value for *medium* was smaller than for *small* (Fig. 2). On average, more than a fifth of studies used size descriptors without providing any quantitative size information or definition (Table 3) to explain what size they refer to, so that their usage did not reliably communicate size information or permit accurate-size comparisons between studies.

Area is used less often than volume to quantify landslide size, as is implied in Fig. 3 where some of the size descriptor classes do not register any data. As for volume (Fig. 1), there is a wide range for several of descriptors, in particular for giant, gigantic, and mega. Some of the inconsistency is particularly interesting because, for example, *mega* implies one million (m^2) (from Greek origin), but it has been applied to landslides with areas both less than and far in excess of one million m^2; the same can be said for *giant* and *gigantic*, which, etymologically, both imply areas of billions of m^2, yet include values far above and below that.

Looking at the frequency distribution of landslides for which quantitative size information is provided in our sample data (for volume), the modal landslide size was 10^7 m^3, with the majority between 10^6 and 10^{11} m^3 (Fig. 4). There is a rapid decay in frequency for landslides larger than 10^{11} m^3 and a less rapid decay for landslides smaller than 10^6 m^3 (Fig. 4). This deviates somewhat from the general magnitude-frequency distribution of landslides, in which smaller landslides are more frequent than larger landslides, other than the rollover effect (i.e. under-representation) commonly

Table 3 Results of the Scopus search, giving the number of hits returned for each size descriptor (used in titles, abstracts, and keywords), and the presence of quantitative size data from within the entire article for the first 100 articles (after sorting by relevance)

Descriptor	Search hits	First 100 results sorted by relevance				
		Size quantified	Size not quantified	Not accessible	Not in English	Irrelevant or duplicated
Gigantic	45	25	4	3	3	10
Giant	288	72	16	7	0	5
Mega	69	30	22	0	0	17
Huge	213	33	29	31	1	6
Massive	340	33	31	25	2	9
Extremely big	3	1	0	0	2	0
Very big	1	0	0	0	1	0
Big	108	10	8	21	1	60
Extremely large	12	4	2	5	0	1
Super large	4	2	0	2	0	0
Very large	50	23	5	5	1	16
Large	3473	49	25	18	0	8
Medium	149	9	9	18	5	59
Small	796	25	23	21	2	29
Very small	13	2	1	2	1	7
Tiny	8	0	0	1	0	7
Totals/averages	5572	35%	22%	21%	3%	19%

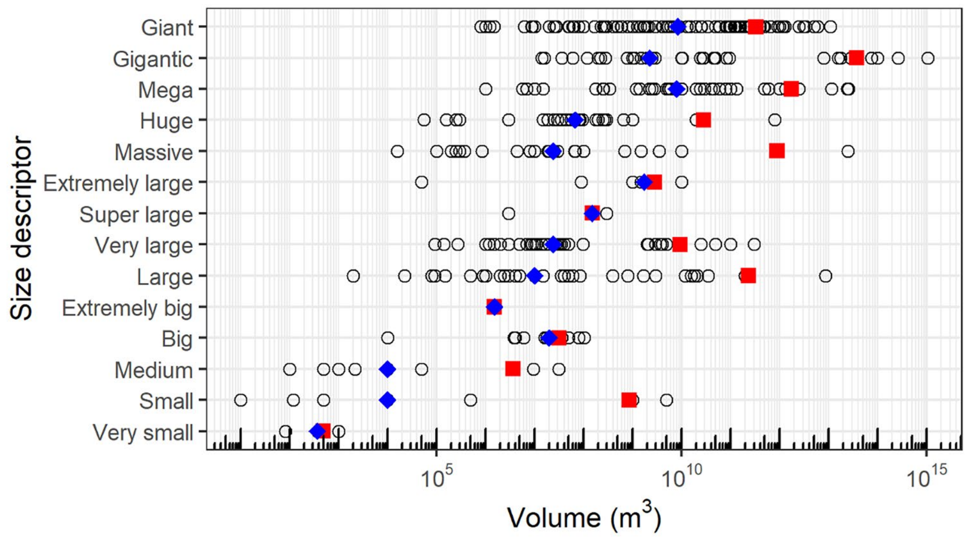

Fig. 1 The volume of landslides described by different-sized descriptors, with open circles representing individual landslides and the blue diamond and red square the median and mean values respectively

observed at the smaller end of distributions. We speculate that the distribution of Fig. 4 likely points to the bias researchers have in studying larger landslides, with a tendency to ignore or not investigate smaller landslides (e.g. in the range of 10^1 to 10^5 m^3) even though they occur more frequently in nature.

A new size classification system for all landslide types

Constraints for a system

A challenge in establishing a widely applicable size classification and size descriptors is that landslide sizes span many orders of magnitude with no theoretical limits. The upper end of the size range is limited only by the maximum permittable relief construction that planetary bodies will allow. Practical limits could be envisaged for certain applications; for example, sand-grain size might be a suitable limit for geomorphologists studying the avalanching of sand grains down a dune face. For engineering applications, a practical upper limit may be the maximum credible size of landslides that could affect a site of interest (with size constrained by the available topographic relief). Different practical limits for different applications or landslide types add challenge to establishing a universally applicable classification system, but the system we propose here is intended to have usage for a wide range of landslide types and applications with no theoretical limits on size. It achieves

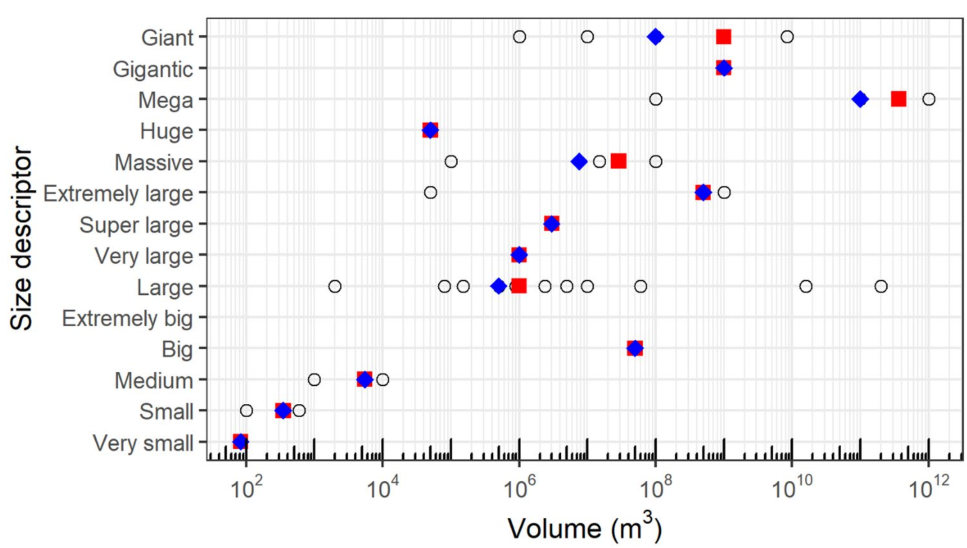

Fig. 2 Definitions for different size descriptors (for landslide volume). These refer to papers in which a specific size threshold is stated, e.g. “large refers to landslides of volume x”. When there was a range given, we used the lower value. Open circles represent individual definitions from a single paper, and the blue diamond and red square the median and mean values respectively for all definitions of that descriptor

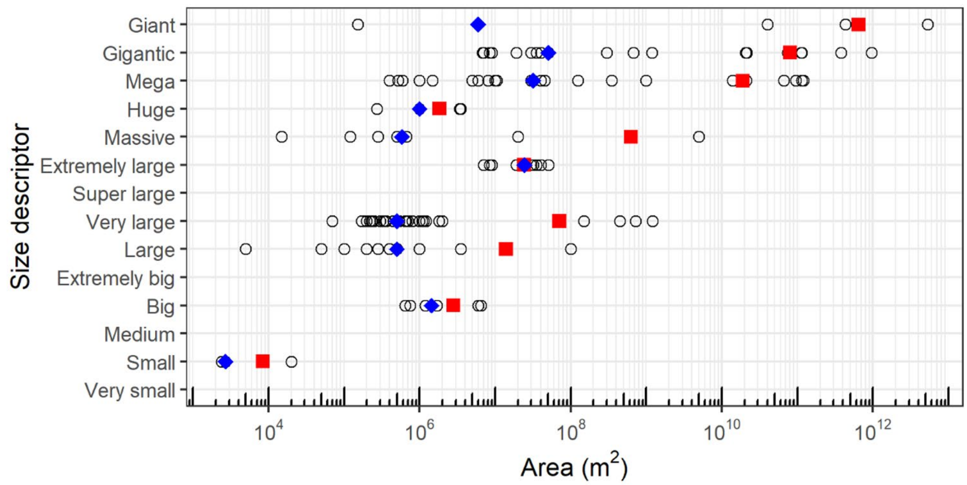

Fig. 3 The area of landslides described by different-sized descriptors, with open circles representing individual landslides and the diamond and square the median and mean values respectively

this by adopting numerical classes, similar to that of Jakob (2005) for debris flows (Table 1), but by allowing its infinite extension to ever smaller or ever larger sizes as needed. A challenge with such a system of infinite extension is how to assign intuitive and sensible size descriptors to each size class. We do not attempt to do this, but instead suggest several size descriptors that cover a range of common or commonly reported sizes. We opted to include size descriptors because they can be useful for conveying simple information about landslide size, either in scientific literature or in communicating landslide science. Indeed, their use (even if inconsistent) seems to be commonplace in the landslide literature.

The basic structure of the system

Our proposed system presented in Table 4 is for use with any landslide type of any size. The units are cubic metre and square metre

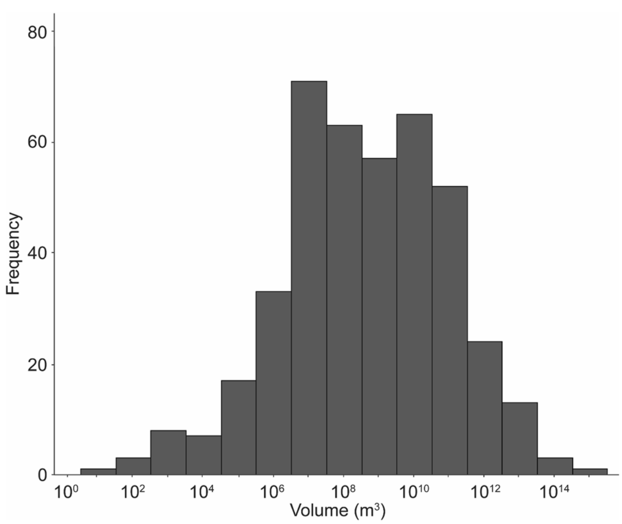

Fig. 4 Frequency distribution for landslides of different volumes reported in the literature sampled

for volume and area, respectively (rather than km^3 or hectare, etc.). This is consistent with the coherent derived units, from the base unit of metre (m), of the International System of Units (SI units). The system uses numeric (integer) classes, which increase by one whole order of magnitude (for volume) for consistency. The class number (i.e. the 6 in Class 6) represents the power of 10 exponent for that size class (for volume, m^3), to keep the classification system easy to remember and follow. For example, Class 6 represents landslides in the order of 10^6 m^3. There is no theoretical limit on the number of classes that could be used in this system. For convenience, the maximum class presented in Table 4 is Class 14 (10^{13}–10^{14} m^3) and the minimum is Class − 3 (10^{-3}–10^{-2} m^3). For reference, the largest landslide (10^{15} m^3) described in our literature analysis would be a Class 15 and the smallest (10^1 m^3) would be Class 1.

For each size class, there is a quantitative value for both volume and area magnitude, two of the most commonly used measures of landslide size. To provide consistency between area and volume, we used a mean empirical landslide area-volume scaling relationship to derive equivalent area for each volume class in our classification system (Table 4). Leong and Cheng (2022) compiled 22 different scaling relationships developed from various landslide datasets around the world and computed the mean constants α (0.033) and β (1.325), which we used here to calculate the landslide area (A_L) for each landslide volume (V_L) using the rearranged formula:

$$V_L = \alpha A_L{}^{\beta} \quad (1)$$

We rounded the resulting area to the nearest half order of magnitude, which helped to provide a distinction between each size class. Even though relationships between area and volume are inconsistent across different landslide types, we believe that by using average scaling constants derived from multiple relationships, the values will be appropriate for many landslides. There may be situations when a landslide's volume fits into one class but its area fits into a different class (i.e. a different row of Table 4). In these situations, we recommend using the volume rather than the area when choosing a size class. In general, it is more useful to describe the volume of a landslide than its area; and indeed, volume was far

Table 4 Proposed universal landslide size classification with numeric classes, descriptors, and minimum volume (m^3) and area (m^2) equivalent quantities. While the table here presents classes − 3 to 14, the classes can be extended larger or smaller indefinitely. Below are recommended descriptors to be avoided or alternatives

Proposed universal classification			
CLASS	Descriptor	Minimum volume (m^3)	Minimum area (m^2)
14	Monster (trillions)	≥ 100,000,000,000,000	≥ 500,000,000,000
13		≥ 10,000,000,000,000	≥ 100,000,000,000
12		≥ 1,000,000,000,000	≥ 10,000,000,000
11	Giant (billions)	≥ 100,000,000,000	≥ 1,000,000,000
10		≥ 10,000,000,000	≥ 500,000,000
9		≥ 1,000,000,000	≥ 100,000,000
8	Large (millions)	≥ 100,000,000	≥ 10,000,000
7		≥ 10,000,000	≥ 1,000,000
6		≥ 1,000,000	≥ 500,000
5	Medium (thousands)	≥ 100,000	≥ 100,000
4		≥ 10,000	≥ 10,000
3		≥ 1000	≥ 1000
2	Small (ones)	≥ 100	≥ 500
1		≥ 10	≥ 100
0		≥ 1	≥ 10
− 1	Very small (thousandths)	≥ 0.1	≥ 1
− 2		≥ 0.01	≥ 0.5
− 3		≥ 0.001	≥ 0.1
Size descriptor terms to be avoided or alternatives			
Extreme, extremely, avoid because of the connotation to the *extreme end of a distribution*			
Massive, avoid because of the alternative usage related to a material's lack of heterogeneity			
Catastrophic, avoid because even a tiny landslide could have catastrophic consequences			
Gigantic, a synonym of giant, could be used in place of giant			
Great, mega, suitable alternatives to large. Equivalents of million in the SI unit system			

more commonly used to describe landslide size according to our Scopus literature search.

Size descriptors

We have included six size descriptors, to assist with landslide descriptions and landslide-size groupings, very small, small, medium, large, giant, and monster, in increasing size order. Each is separated by three orders of magnitude (Table 4; Fig. 5). Inevitably, some of the terms deviate from existing definitions but we believe that those suggested here are logical, simple, and intuitive and will encourage more consistent usage. Where appropriate, we have retained commonly used descriptors (e.g. medium and large) and maintained consistency in their quantitative equivalents. For example, we use the commonly used term *giant* and adopt its existing usage by several researchers to describe km^3-scale landslides (Classes 9 to 11 in our system). We have aligned terms with the SI Units or their etymological roots, if logical to do so. For example, the term *monster* is the Greek source word for the SI prefix *tera* (trillion), so we have suggested this for landslides on the order of trillions of cubic metres (Classes 12 to 14). Likewise, giant is the Greek source word for the SI unit prefix *giga* (billion), and so in our classification, it represents landslides on the order of billions of cubic metres (Classes 9 to 11). We have suggested the term *large* rather than the terms *mega* or *great* (both related to the SI prefix for millions) for Classes 6 to 8, due to *large* being a common English word and having been widely used as a size descriptor (Table 3). We have avoided terms that convey other meanings in geoscience (e.g. massive, which describes a material's homogeneity) and avoided terms that may also convey impact (e.g. catastrophic, moderate, super, great, terrific).

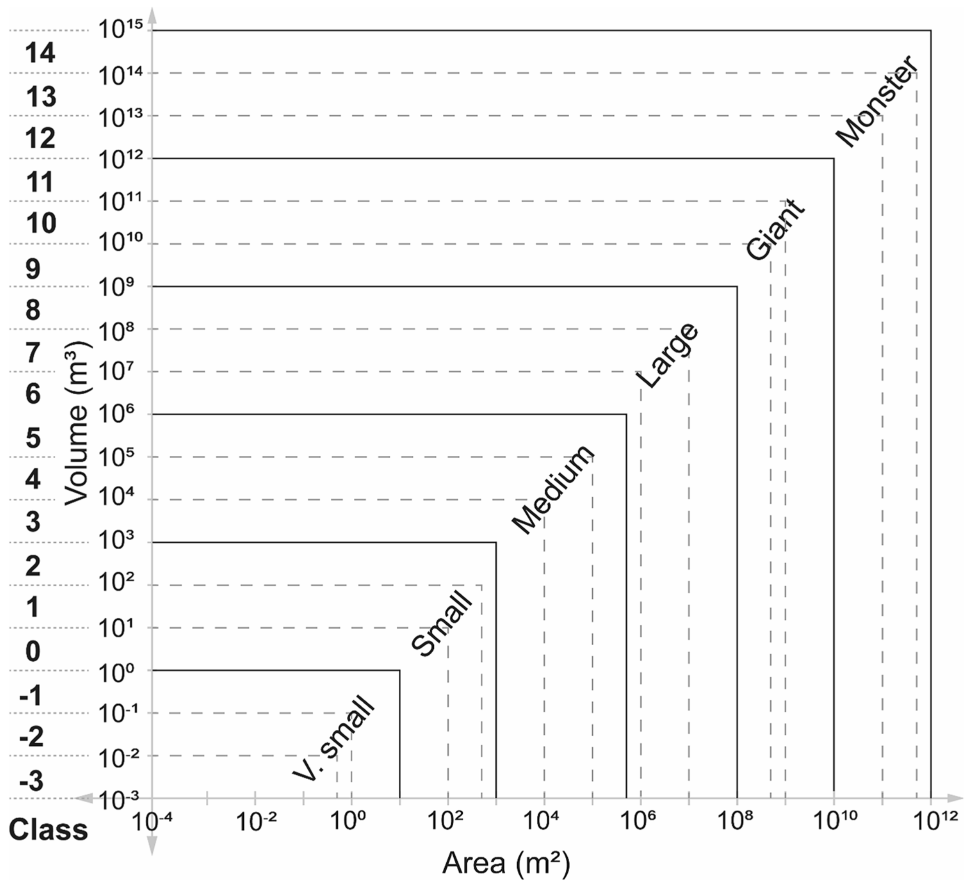

Fig. 5 Graphical presentation of the proposed universal landslide size classification with volume and area equivalent quantities.

We have overall opted for simplicity in our use of size descriptors, in place of comprehensiveness. We have not defined descriptors for landslides exceeding the monster or below the very small size classes, because these are considered rare (Fig. 4) and unlikely to benefit from grouping into a size range, though there is nothing to preclude the subsequent addition of size descriptors for other classes if the need arose in the future. The small number (6) of descriptors and the systematic separation across three orders of magnitude in our system could be argued to have unequal usefulness and discrimination across the range of landslide sizes typically described in the literature (Fig. 4). For example, *very small* and *small* landslides (according to our system) are described relatively infrequently (Fig. 4). We have opted to include these size descriptors (small and very small) because landslides of these sizes can still be impactful (e.g. as a hazard) and are frequent in nature. By defining them here also means they are less likely to be used inappropriately or inconsistently for larger events as has previously been the case (e.g. Fig. 1). The logarithmic scale used means that there is poorer discrimination for larger events. For example, the size range (of ~ 9998 m^3) captured by *small* is vastly smaller than the size range (of ~ 0.998 billion m^3) captured by *giant* in absolute terms. It could be argued that additional terms or qualifiers (such as *very large*) (or indeed a non-logarithmic scale) would help to further distinguish between the landslides in the larger size classes. However, we suggest that a simple system, with fewer terms, is more likely to be more readily used, and the terms better comprehended, than a system that has a multitude of terms. If discrimination is required, then the numerical classes can be used, but moreover, we encourage people to, wherever possible, provide an exact quantitative measure of size for the landslides they describe, rather than rely on descriptors alone.

Conclusion

The size of a landslide is of fundamental importance for a range of landslide processes, impacts, and applications of landslide science, especially hazard assessment and mitigation. It is therefore useful to be able to consistently describe landslide size, but to date, size descriptions have been inconsistent. We found the most commonly used descriptor to be the term *large*, which was used to refer to landslide volumes spanning ten orders of magnitude. Most terms similarly had wide variance in the size they referred to, and some were used in the opposite order to what would be intuitively expected (e.g. big was smaller than extremely big). We argued that a universal size classification system would help to encourage more consistent and logical usage of size descriptors, to improve the way that landslide scientists communicate between each other and beyond. We proposed a universal classification scheme that maintains consistency with some existing usage, but attempts to simplify and make use of intuitive terms and align with the International System of Units where possible. The system uses numeric size classes that follow a logarithmic scale and in theory has no upper or lower size limit. We suggest six size descriptors (very small, small, medium, large, giant, and monster) to capture some of the most common or commonly reported landslide sizes. Our universally applicable classification system does not make existing type-specific landslide classifications redundant, such as those for snow avalanche and debris flow classifications. Whatever system is used to describe the size of landslides, we encourage people to clearly define the terms they use or state which system they are using and whenever possible quantify the landslide size. Doing so will improve landslide communication.

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Author contribution

Both authors contributed to the study conception, design, and data collection. Data analyses and graphics production were performed by Simon Cook. The manuscript was written by Sam McColl with input and edits from Simon Cook.

Data availability

The data from our Scopus literature searches are available in three supplementary spreadsheets: (i) landslide volumes for each size class; (ii) lower thresholds of landslide volume for each size class, where they have been stated in the searched literature; and (iii) landslide areas for each size class.

Declarations

Conflict of interest The authors have no conflicts of interest to declare.

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