BIODIVERSITY AND SPECIES SUCCESSION OF THE BLACK VEN – SPITTLE'S LANDSLIDE COMPLEX, DORSET

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Many landslides are known locally as important landforms that may contain rare or protected species of flora or fauna. Landslides, especially active ones, may present complex, unique habitats for such species to thrive. Difficulties posed to development or agriculture also tends to reduce anthropogenic influences. Landslide terrains are often subject to careful investigation and monitoring during any remediation or chance discovery of a particular organism. However, few detailed studies have been carried out on the ecology of landslides in Britain. Thus, the ecological value of landslides is little known and the impact of remediation is not fully understood. Fundamental knowledge of the mechanisms that control the biodiversity and species succession on British landslides is lacking. This paper describes the results of a preliminary survey to examine plant species succession and biodiversity on a section of the Black Ven landslide complex in West Dorset. Eight sites were examined in areas (zones) of the complex representing different rates of movement: stable, incipient (recently active) and active. In total, 39 plant species were identified and described. The greatest species diversity was found to be present in the active zone. The active zone also coincided with the lowest ground cover. Three notable (locally important) species were found in the active zone whilst none was found in the stable zone. Although only a small-scale study, we have demonstrated that there is value in considering further research into plant succession in landslides, and that studies of unimproved habitats might usefully consider landslide activity as an important factor. This now forms part of a larger study at Portsmouth to investigate fundamental relationships between ground disturbance and ecosystem services and implications for planning and engineering decisions.

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BIODIVERSITY AND LANDSLIDES

Landscape disturbance performs an important role in the creation and maintenance of ecosystems. However, a review by Stokes *et al.* (2007) found there to be little understanding of the vegetation-landform interactions on many landslides. This study presents results of an investigation into the plant biodiversity of the Black Ven landslide complex, and an assessment of this site for future investigation.

Landslides provide important areas of disturbance on which plant succession may occur and thereby create and enhance local biodiversity. The principle of ecological succession on landslides is well established (e.g. Walker *et al.*, 1996; Stokes *et al.*, 2007; Myster and Walker, 1997) with the nature and rate of succession being determined by changes in soil type, available nutrients, light, wind and hydrology. Re-population following such disturbance is considered 'primary' where colonisation occurs on newly exposed rock or previously unpopulated soils. 'Secondary' succession occurs where an area has been previously occupied by biological communities but they have been reduced in size due to events such as forest fires, harvesting and hurricanes. Seeds and/or roots of plants survive in these areas and are able to re-populate (Walker and Moral, 2003; Mongillo and Zierdt-Warshaw, 2000). Re-population is determined by environmental conditions and the availability of propagules (e.g. seeds, spores or root fragments), germination sites and nutrient availability (Walker *et al.*, 1996; Walker, 1999). Succession is then secured as plants initiate recovery, preparing soil for further succession; stabilising soil by root growth, fixing nitrogen, increasing moisture-holding capacity, increasing temperature in the lower canopy and reducing exposure to wind (Connell and Slatyer, 1977).

In ecological terms, landslides are usually considered as relatively discrete upper, middle and lower zones (Walker *et al.*, 1996; Lundgren, 1978) based on landslide morphology and its impact on properties important for plant growth. The upper zone, typically near the head-scarp, may be characterised by partial or total removal of soil mixed with areas of little movement. Here, relatively stable, low-nutrient soils are typically colonised by slower growing, larger vascular plants. If movement is persistent, this can lead to slow colonization. The middle zone, typically associated with the landslide zone of transportation, is characterised by scouring and movement of soil in transition from above. The lower zone, analogous to the zone of accumulation, is characterised by a combination of broken plant parts and the deposition of organics and soils from upslope. Soil organic matter and nutrients are generally higher in the lower zone (Adams and Sidle, 1987; Guariguata, 1990; Lundgren, 1978). This, and a higher occurrence of propagules, often leads to more rapid succession here than elsewhere in the landslide system, typically by pioneer species (Guariguata, 1990; Myster and Walker, 1997). This simple pattern is often complicated by variations in geology, drainage, movement rates and the presence of vegetation 'islands' that remain fairly intact

during downslope movement.

Although elegant, this classification system has been developed on recently active, relatively simple landslides or landslide clusters. Terminologies such as upper, middle and lower slopes are less meaningful on complex landslides or degraded slopes. A second aim of this study is therefore to consider how best to represent the ecology-landscape relationship on terrains such as those found on the Jurassic Coast.

Study area

The study area is a section of the Spittles Slope on the western flank of Black Ven (Figure 1). The geology, geomorphology and landslide history of this location are well described by previous studies, lately by Barton *et al.*, (2011) and Gallois (2009), and also by earlier investigations (Allison, 1992; Brunsden and Moore, 1999; Cooper, 2007; House and Lister, 1989; Gallois and Davis, 2001; Gibson, 2005; Jones and Lee, 1994). All sites in this study are underlain by relict landslides formed within the Upper Greensand Formation.

Areas of interest to this study were identified by previous geomorphological mapping (Gibson, 2005), inspection of satellite (Bing Maps and Google Earth) and airborne imagery (NERC ARSF Flight UR08-01-140). Three zones, representative of different landslide age and activity, were identified:

1) An 'active' zone currently undergoing movement, with freshly exposed scarps and tension cracks.
2) An 'incipient' zone which has undergone movement in the past decade (Allison, 1992; Gallois, 2009) but is currently relatively stable.
3) A 'stable' control zone considered to be an ancient and currently stable rotated block. This area is periodically used for grazing cattle.

Due to unusually high levels of landslide activity in the area in 2012, this study concentrated on the upper slopes of the landslide.

The diversity of flora within the Black Ven landslide complex has been researched by the Dorset Flora Group and in particular by a Mr. Bryan Edwards. The details of the species found and the approximate locations are held by the Dorset Environmental Records Office. This list covering the countryside between Lyme Regis and Charmouth indicates the presence of 250 different plant species in or near the field area, of which 79 are of protected status. The unstable nature of soft cliffs and slopes constantly creates bare ground and suppresses ecological succession. In other situations that are more stable, herb-rich pioneer plant communities are transitional features, they naturally progress into closed grassland followed by scrub - the instability of soft cliff slopes suppresses this change maintaining a continuity of early successional vegetation (Whitehouse, 2007).

Methodology

Standard techniques (Colinvaux, 1973), a combination of walking transects across and between activity zones and 'random' quadrat surveys within each zone, were used in the present study. This ensured representative coverage with minimal bias towards specific species or landforms. Walking transects, often used on landslide surveys (e.g. Walker *et al.*, 1996), were 1 m wide and 20 m in length, with start and end points identified using handheld GPS. Within each transect plants species and their abundance, by % cover of surface area, were recorded. Results allowed an understanding of the plant communities present and provided reconnaissance data for the approximate location of detailed plot (quadrat) surveys. Plot surveys, using a 0.5 m x 0.5 m quadrat, were carried out at locations within each zone by throwing the quadrat in the air and allowing it to fall to the ground. At each of these semi-random sites, a record was made of the type and abundance of individual plant species. Abundance of each species, counted as number of individual plants (for mosses % of the total area within the quadrat) was described using a modification of the Braun–Blanquet system (Poore, 1955). Plants were identified using reference to key texts (Press and Gibbons, 2002; Sterry, 1997) and with the assistance of Mr. B. Edwards of the Dorset Environmental Records Office. Transects and plots were

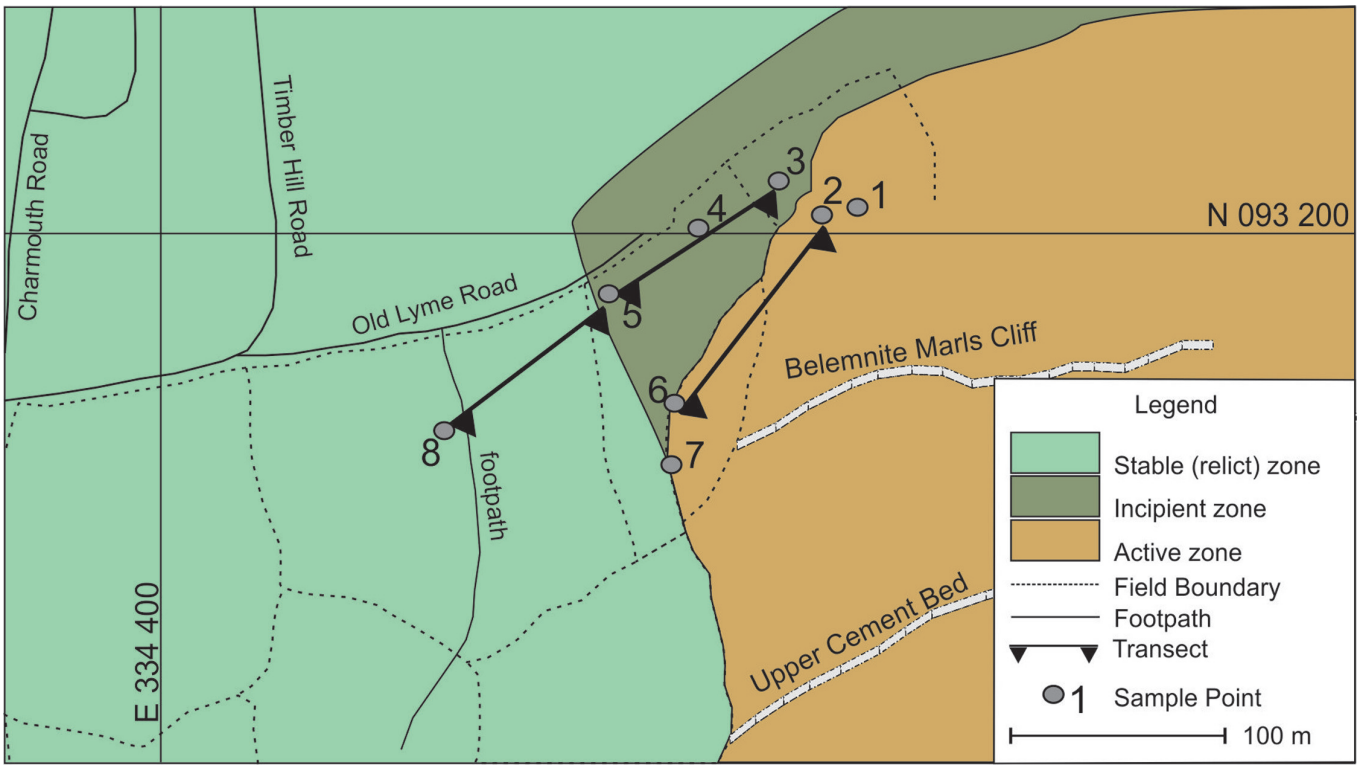

Figure 1. *Map of the study area showing the three areas of activity (stable, incipient and active) and the locations of sampling points and transects.*

undertaken during 23-26 July 2012 when it was considered most likely that the majority of plants would be in flower or full growth.

Results

Thirty-nine different species of plants (including one unidentified species of grass), from three groups (Mosses, Forbs and Grasses) were found in survey areas as detailed in Table 1. Three Dorset notable species plants (Fairy Flax (*Linum catharticum*), Rough Hawkbit (*Leontodon hispidus*) and common Birds Foot Trefoil (*Lotus corniculatus*)) were identified (Figure 2). Dorset notable species are chosen as indicators of good unimproved or semi-improved habitat to assist in the selection of Sites of Nature Conservation Interest. Of the other species found, six (Coltsfoot (*Tussilago farfara*), Prickly Sow Thistle (*Sonchus asper*), Creeping Bent (*Agrostis stolonifera*), Black Bent (*Agrostis gigantean*), Annual Meadow Grass (*Poa annua*) and Parsley Piert (*Aphanes arvensis*)) are considered to be pioneer plants on rough and disturbed ground (Edwards, 2012).

The greatest plant species diversity, by both individual counts and total amount, was found within the 'active' zone. This zone also contained the greatest species diversity of forbs and mosses (Figure 3). Colts foot (*Tussilago farfara*) and Prickly Sow Thistle (*Sonchus asper*), which are considered pioneer species in this region (Edwards, 2012), were only found within the most active zones of the site.

Within the 'incipient' zone, plants tended to be larger, more vascular in type than the very active zone. Species such as Self Heal (*Prunella vulgaris*), Agrimony (A*grimonia eupatoria*) and Hawkbit (*Leontodon*) were all found within this zone. These plants are longer lived annuals and short lived perennials (Press and Gibbons, 2002). These take longer to grow and reproduce (Sterry, 1997) and therefore are more likely to be secondary successional species.

The lowest plant biodiversity was found in the 'stable' control zone, with the fewest plant species, lowest count of each plant family with no moss encountered during the survey. Here, there were fewer vascular plants, mainly comprising grasses. This is also expected in the succession of plants (Stohlgren, 2006), but was also expected in a region currently used as grazing pasture, as are most areas in the region that are stable.

Discussion

We believe this study to be the first of its type on a complex landslide terrain in the UK. Results demonstrate that there was considerable variation in plant distribution within the study area and that these differences could be related to position within in the landslide terrain. The greatest plant biodiversity and largest number of plant families were found in the active zone. This zone was also associated with the lowest measure of ground

Plant Category	Plant Name	Zone/Transect Number								Total
		Active			Incipient				Stable	
		1	2	7	3	4	5	6	8	
Mosses	*Brachythecium velutinum* Velvet Feather-moss	20								20
	Bryophyta Moss		1							1
	Bryum Moss				1					1
Forbs	*Agrimonia eupatoria* Agrimony						1			1
	Aphanes arvensis Parsley Piert			6			8	6		20
	Artemisia absinthium Wormwood	4								4
	Cerastium fontanum Common Mouse-ear			10						10
	Cirsium arvense Creeping Thistle							3		3
	Convolvulus arvensis Field Bindweed			1						1
	Crepis capillaris Smooth Hawk's Beard	3								3
	Equisetum arvense Field Horsetail			2					1	3
	Euphrasia nemorosa Eye Bright	4								4
	Fragaria vesca Wild Strawberry			3						3
	Geranium dissectum Cut-Leaved Crane's-bill							3		3
	Hypochaeris radicata Common Cat's - Ear		1							1
	Leontodon hispidus Rough Hawkbit	2	2							4
	Leontodon saxatilis Lesser Hawkbit	4		3	6		10			23
	Linum catharticum Fairy Flax	2				4	10			16
	Lotus corniculatus Common Bird's Foot Trefoil	30		20			15			65
	Plantago lanceolata Ribwort Plantain	5	4		8	3			1	21
	Prunella vulgaris Self Heal	1		6			20			27
	Ranunculus repens Creeping Buttercup					4				4
	Ranunculus sardous Hairy Buttercup			2			9			11
	Sonchus asper Prickly Sow-thistle							2		2
	Taraxacum officinale Common Dandelion								1	1
	Trifolium repens White Clover	20	12	15	20	25	25	20	15	152
	Tussilago farfara Colts foot	10	10	10						30
	Urtica dioica Common Nettle							2		2
	Veronica persica Common Field Speedwell	8			8					16
	Vicia sativa Common Vetch		2							2
Grasses	*Poa annua* Annual Meadow-grass	20	20	2	15	30	5	25	40	157
	Agrostis gigantea Black Bent			15	15	10	5			45
	Agrostis stolonifera Creeping Bent		4					6		10
	Anthoxanthum odoratum Sweet Vernal Grass	20					10			30
	Arrhenatherum elatius False Oat-grass				15					15
	Dactylis glomerata Cocksfoot Grass	20	10			5				35
	Holcus lanatus Yorkshire-Fog							30	5	35
	Holcus mollis Creeping Soft Grass	15	6	4	10	15				50
	Grass (one species unidentified)						5		10	15
Total	39 Different Plant Species	188	72	99	98	96	123	97	63	836
	Moss coverage as % of total quadrat area	35	25		20					

Table 1. *Plant species and numbers for each sampling location.*

Figure 2. *Dorset notable species identified within the study area. (**a**) Common Bird's Foot Trefoil (Lotus corniculatus), (**b**) Fairy Flax (Linum catharticum) and (**c**) Rough Hawkbit (Leontodon hispidus).*

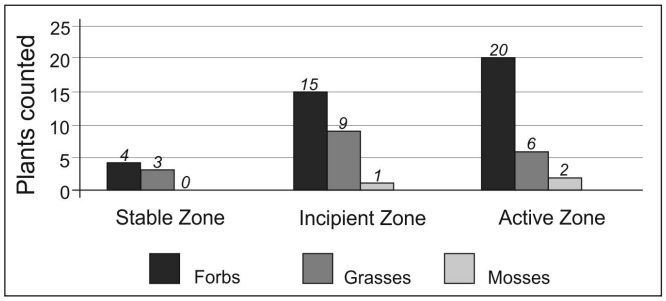

Figure 3. *Plants counted within each family and activity zone.*

coverage, a result of the presence of fresh tension cracks. The lowest amount of plant biodiversity, with little species variation, was found to be in the stable zone, where ground coverage was also found to be greatest. Two species considered to be pioneer varieties were identified in the active zone. Three Dorset notable species were identified in the active and incipient zones.

Though limited by a relatively small scope (single survey and 8 survey points) the results are in broad agreement with work published on landslide sites in other regions, which reveal an increase in species diversity and a reduction in ground cover with increasing distance from the head of the landslide. However, in the case of Black Ven, and other complex landslides, we suggest it is not always appropriate to discuss biodiversity in terms of upper, middle and lower slopes. Here we suggest that it may be more appropriate to consider landslide biodiversity with respect to the age and degree of landslide activity. Longer-term study, including the whole Black Ven landslide complex amongst others, is currently underway to investigate this topic further.

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