

## **Anthropogenic disturbances alter the conservation value of karst dolines**

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**Table E1** Diameter and depth values of the dolines (D1: dolines with little disturbance; D2: dolines with medium disturbance; D3: dolines with high disturbance) in Kras (Slovenia), Mecsek, forested site in Bükk and non-forested site in Bükk (Hungary)

	<b>diameter (m)</b>	<b>depth (m)</b>
<b>Kras</b>		
D1 – 1	55	12
D1 – 2	40	6
D1 – 3	40	10
D2 – 1	70	10
D2 – 2	50	8
D2 – 3	30	5
D3 – 1	60	8
D3 – 2	55	9
D3 – 3	40	9
<b>Mecsek</b>		
D1 – 1	55	13
D1 – 2	65	15
D1 – 3	105	16
D2 – 1	50	10
D2 – 2	70	10
D2 – 3	100	15
D3 – 1	85	14
D3 – 2	55	10
D3 – 3	65	13
<b>Bükk, forested site</b>		
D1 – 1	70	12
D1 – 2	85	12
D1 – 3	70	10
D2 – 1	85	10
D2 – 2	85	12
D2 – 3	80	10
<b>Bükk, non-forested site</b>		
D1 – 1	85	15
D1 – 2	85	7
D1 – 3	65	12
D2 – 1	70	12
D2 – 2	75	12
D2 – 3	55	7
D3 – 1	70	15
D3 – 2	60	7
D3 – 3	70	7

**Table E2** List of cool-adapted plant species in Kras (Slovenia), Mecsek, forested site in Bükk, and non-forested site in Bükk (Hungary)

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**Kras:** *Aconitum lycoctonum*, *Actaea spicata*, *Anemone nemorosa*, *Asarum europaeum*, *Athyrium filix-femina*, *Campanula trachelium*, *Cardamine enneaphyllos*, *Carex digitata*, *Cephalanthera damasonium*, *Clematis vitalba*, *Corylus avellana*, *Cruciata glabra*, *Cyclamen purpurascens*, *Dryopteris filix-mas*, *Euphorbia dulcis*, *Fragaria moschata*, *Galanthus nivalis*, *Geranium robertianum*, *Geum urbanum*, *Hedera helix*, *Hepatica nobilis*, *Heracleum sphondylium*, *Lamium galeobdolon* subsp. *montanum*, *Lamium orvala*, *Lathyrus venetus*, *Lathyrus vernus*, *Lonicera xylosteum*, *Melica nutans*, *Mercurialis perennis*, *Moehringia muscosa*, *Lactuca muralis*, *Neottia nidus-avis*, *Neottia ovata*, *Oxalis acetosella*, *Platanthera bifolia*, *Polygonatum multiflorum*, *Polypodium vulgare*, *Primula vulgaris*, *Pseudofumaria alba*, *Pulmonaria officinalis*, *Rosa arvensis*, *Salvia glutinosa*, *Symphytum tuberosum*, *Thalictrum aquilegifolium*, *Viola mirabilis*, *Viola reichenbachiana*.

**Mecsek:** *Aremonia agrimonoides*, *Asarum europaeum*, *Athyrium filix-femina*, *Bromus ramosus*, *Cardamine bulbifera*, *Cardamine impatiens*, *Carex digitata*, *Carex pilosa*, *Carex remota*, *Carex sylvatica*, *Chrysosplenium alternifolium*, *Circaea lutetiana*, *Dryopteris affinis*, *Dryopteris carthusiana*, *Dryopteris filix-mas*, *Euphorbia amygdaloides*, *Festuca drymeja*, *Galium odoratum*, *Glechoma hirsuta*, *Hepatica nobilis*, *Hordelymus europaeus*, *Lamium galeobdolon* s.l., *Lathyrus vernus*, *Mercurialis perennis*, *Milium effusum*, *Oxalis acetosella*, *Paris quadrifolia*, *Polygonatum multiflorum*, *Pulmonaria officinalis*, *Rosa arvensis*, *Rumex sanguineus*, *Ruscus hypoglossum*, *Sanicula europaea*, *Stachys sylvatica*, *Symphytum tuberosum*, *Veronica montana*, *Viola reichenbachiana*.

**Bükk, forested site:** *Aconitum moldavicum*, *Aconitum variegatum*, *Actaea spicata*, *Anthriscus nitida*, *Asarum europaeum*, *Astrantia major*, *Athyrium filix-femina*, *Chrysosplenium alternifolium*, *Daphne mezereum*, *Dryopteris carthusiana*, *Dryopteris dilatata*, *Festuca altissima*, *Geranium phaeum*, *Hesperis matronalis*, *Hordelymus europaeus*, *Hypericum maculatum*, *Impatiens noli-tangere*, *Lunaria rediviva*, *Maianthemum bifolium*, *Moneses uniflora*, *Myosotis sylvatica*, *Oxalis acetosella*, *Polygonatum verticillatum*, *Primula elatior*, *Ribes alpinum*, *Rosa pendulina*, *Senecio ovatus*, *Silene dioica*, *Soldanella hungarica*.

**Bükk, non-forested site:** *Aconitum moldavicum*, *Aconitum variegatum*, *Alchemilla monticola*, *Astrantia major*, *Botrychium lunaria*, *Bupleurum longifolium*, *Carex pallescens*, *Carlina acaulis*, *Cirsium oleraceum*, *Dianthus deltoides*, *Euphorbia lucida*, *Festuca ovina*, *Filipendula ulmaria*, *Galium boreale*, *Gentiana pneumonanthe*, *Gentianella austriaca*, *Geranium palustre*, *Gladiolus imbricatus*, *Hypericum maculatum*, *Iris sibirica*, *Molinia caerulea*, *Myosotis sylvatica*, *Nardus stricta*, *Ophioglossum vulgatum*, *Oxalis acetosella*, *Parnassia palustris*, *Peucedanum palustre*, *Polygonatum verticillatum*, *Potentilla erecta*, *Primula elatior*, *Rosa pendulina*, *Succisa pratensis*, *Thymus pulegioides*, *Viola canina*.

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**Table E3** List of moist-adapted plant species in Kras (Slovenia), Mecsek, forested site in Bükk, and non-forested site in Bükk (Hungary)

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**Kras:** *Aconitum lycoctonum*, *Arabis turrata*, *Asarum europaeum*, *Carex flacca*, *Colchicum autumnale*, *Helleborus multifidus* subsp. *istriacus*, *Hieracium racemosum*, *Lamium orvala*, *Lathyrus pratensis*, *Lilium bulbiferum*, *Moehringia muscosa*, *Neottia ovata*, *Oxalis acetosella*, *Salvia glutinosa*, *Stenactis annua*, *Symphytum tuberosum*, *Thalictrum aquilegifolium*, *Urtica dioica*.

**Mecsek:** *Ajuga reptans*, *Aremonia agrimonoides*, *Asarum europaeum*, *Athyrium filix-femina*, *Carex digitata*, *Carex remota*, *Carex sylvatica*, *Chrysosplenium alternifolium*, *Circaea lutetiana*, *Crataegus laevigata*, *Dryopteris carthusiana*, *Festuca drymeja*, *Galium aparine*, *Geranium robertianum*, *Lamium galeobdolon* s.l., *Lathyrus vernus*, *Lysimachia nummularia*, *Mercurialis perennis*, *Milium effusum*, *Oxalis acetosella*, *Paris quadrifolia*, *Pulmonaria officinalis*, *Rumex sanguineus*, *Ruscus hypoglossum*, *Sambucus nigra*, *Sanicula europaea*, *Stachys sylvatica*, *Urtica dioica*, *Veronica montana*.

**Bükk, forested site:** *Aegopodium podagraria*, *Athyrium filix-femina*, *Cardamine impatiens*, *Carduus crispus*, *Chaerophyllum aromaticum*, *Chrysosplenium alternifolium*, *Dryopteris carthusiana*, *Festuca gigantea*, *Impatiens noli-tangere*, *Lapsana communis*, *Lunaria rediviva*, *Lysimachia nummularia*, *Oxalis acetosella*, *Ranunculus repens*, *Sambucus nigra*, *Solanum dulcamara*, *Stachys sylvatica*, *Urtica dioica*.

**Bükk, non-forested site:** *Aegopodium podagraria*, *Cardamine pratensis*, *Carex hirta*, *Cirsium oleraceum*, *Euphorbia lucida*, *Filipendula ulmaria*, *Frangula alnus*, *Galium boreale*, *Gentiana pneumonanthe*, *Geranium palustre*, *Gymnadenia conopsea*, *Iris sibirica*, *Lathyrus pratensis*, *Leucanthemum vulgare*, *Linum catharticum*, *Lysimachia nummularia*, *Molinia caerulea*, *Ophioglossum vulgatum*, *Oxalis acetosella*, *Parnassia palustris*, *Peucedanum palustre*, *Potentilla erecta*, *Ranunculus acris*, *Scorzoneroides autumnalis*, *Succisa pratensis*, *Thalictrum lucidum*, *Urtica dioica*, *Viburnum opulus*.

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**Table E4** List of plant species of high conservation importance in Kras (Slovenia), Mecsek, forested site in Bükk, and non-forested site in Bükk (Hungary)

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**Kras:** *Cephalanthera damasonium*, *Cephalanthera longifolia*, *Convallaria majalis*, *Cyclamen purpurascens*, *Dianthus hyssopifolius*, *Galanthus nivalis*, *Helleborus multifidus* subsp. *istriacus*, *Iris graminea*, *Lilium bulbiferum*, *Limodorum abortivum*, *Neottia nidus-avis*, *Neottia ovata*, *Platanthera bifolia*, *Paeonia officinalis*.

**Mecsek:** *Aremonia agrimonoides*, *Dioscorea communis*, *Dryopteris affinis*, *Dryopteris carthusiana*, *Helleborus odorus*, *Hepatica nobilis*, *Lathyrus venetus*, *Ruscus aculeatus*, *Ruscus hypoglossum*.

**Bükk, forested site:** *Aconitum moldavicum*, *Aconitum variegatum*, *Anthriscus nitida*, *Astrantia major*, *Daphne mezereum*, *Dryopteris carthusiana*, *Dryopteris dilatata*, *Epipactis helleborine*, *Festuca altissima*, *Helleborus purpurascens*, *Hesperis matronalis*, *Hypericum maculatum*, *Lunaria rediviva*, *Moneses uniflora*, *Myosotis sylvatica*, *Neottia nidus-avis*, *Polygonatum verticillatum*, *Primula elatior*, *Ribes alpinum*, *Rosa pendulina*, *Sambucus racemosa*, *Silene dioica*, *Thlaspi jankae*.

**Bükk, non-forested site:** *Aconitum moldavicum*, *Aconitum variegatum*, *Alchemilla monticola*, *Anemone sylvestris*, *Astrantia major*, *Botrychium lunaria*, *Bupleurum longifolium*, *Carlina acaulis*, *Centaurea scabiosa* subsp. *sadleriana*, *Dianthus deltoides*, *Festuca ovina*, *Gentiana pneumonanthe*, *Gentianella austriaca*, *Gentiana cruciata*, *Geranium palustre*, *Gladiolus imbricatus*, *Gymnadenia conopsea*, *Helleborus purpurascens*, *Hieracium laevigatum*, *Hypericum maculatum*, *Iris graminea*, *Iris sibirica*, *Iris variegata*, *Lilium martagon*, *Myosotis sylvatica*, *Nardus stricta*, *Ophioglossum vulgatum*, *Parnassia palustris*, *Peucedanum palustre*, *Polygonatum verticillatum*, *Primula elatior*, *Prunella grandiflora*, *Pulsatilla grandis*, *Rosa pendulina*, *Silene italica* subsp. *nemoralis*, *Thlaspi jankae*.

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**Table E5** Comparisons of plant species composition between habitats (D1: little disturbed dolines and D1R: little disturbed plateau), and among disturbance classes in the dolines (D1: little, D2: medium and D3: high disturbance) with one-way analysis of similarities (ANOSIM) in Slovenia (Kras) and Hungary (Mecsek, Bükk). The *p* values in pairwise comparisons were Bonferroni corrected. Significant differences ( $p < 0.05$ ) are indicated by bold *p* values

<b>Kras</b>			<b>Mecsek</b>		
	R	p		R	p
D1 – D1R	0.45	< <b>0.001</b>	D1 – D1R	0.36	< <b>0.001</b>
	0.07	< <b>0.001</b>		0.25	< <b>0.001</b>
D1 – D2	0.10	< <b>0.001</b>	D1 – D2	0.18	< <b>0.001</b>
D1 – D3	0.08	< <b>0.001</b>	D1 – D3	0.26	< <b>0.001</b>
D2 – D3	0.02	0.220	D2 – D3	0.31	< <b>0.001</b>
<b>Bükk, forested site</b>			<b>Bükk, non-forested site</b>		
	R	p		R	p
D1 – D1R	0.23	< <b>0.001</b>	D1 – D1R	0.28	< <b>0.001</b>
D1 – D2	0.52	< <b>0.001</b>		0.39	< <b>0.001</b>
			D1 – D2	0.40	< <b>0.001</b>
			D1 – D3	0.49	< <b>0.001</b>
			D2 – D3	0.28	< <b>0.001</b>

**Table E6** Comparisons of the number of cool-adapted plant species between habitats (D1: little disturbed dolines and D1R: little disturbed plateau), and among disturbance classes in the dolines (D1: little, D2: medium and D3: high disturbance) using the fitted mixed-effect models. The  $p$  values were corrected with the FDR (false discovery rate) method. Significant differences ( $p < 0.05$ ) are indicated by bold  $p$  values

<b>Kras</b>			<b>Mecsek</b>		
	$z$	$p$		$z$	$p$
D1 – D1R	-6.60	< <b>0.001</b>	D1 – D1R	-2.39	<b>0.017</b>
	$X^2$	$p$		$X^2$	$p$
	0.65	0.722		47.92	< <b>0.001</b>
	$z$	$p$		$z$	$p$
D1 – D2	-0.45	0.729	D1 – D2	-3.38	< <b>0.001</b>
D1 – D3	-0.80	0.729	D1 – D3	-6.90	< <b>0.001</b>
D2 – D3	-0.35	0.729	D2 – D3	-3.68	< <b>0.001</b>
<b>Bükk, forested site</b>			<b>Bükk, non-forested site</b>		
	$z$	$p$		$z$	$p$
D1 – D1R	0.05	0.960	D1 – D1R	-5.39	< <b>0.001</b>
D1 – D2	2.35	<b>0.019</b>		$X^2$	$p$
				9.27	<b>0.010</b>
				$z$	$p$
			D1 – D2	-0.55	0.582
			D1 – D3	-2.89	<b>0.009</b>
			D2 – D3	-2.35	<b>0.029</b>

**Table E7** Comparisons of the number of moist-adapted plant species between habitats (D1: little disturbed dolines and D1R: little disturbed plateau), and among disturbance classes in the dolines (D1: little, D2: medium and D3: high disturbance) using the fitted mixed-effect models. The  $p$  values were corrected with the FDR (false discovery rate) method. Significant differences ( $p < 0.05$ ) are indicated by bold  $p$  values

<b>Kras</b>			<b>Mecsek</b>		
	$z$	$p$		$z$	$p$
D1 – D1R	-7.07	< <b>0.001</b>	D1 – D1R	-2.88	<b>0.004</b>
	$X^2$	$p$		$X^2$	$p$
	3.30	0.192		43.26	< <b>0.001</b>
	$z$	$p$		$z$	$p$
D1 – D2	-0.83	0.407	D1 – D2	-4.13	< <b>0.001</b>
D1 – D3	-1.82	0.069	D1 – D3	-6.29	< <b>0.001</b>
D2 – D3	-0.96	0.339	D2 – D3	-2.35	<b>0.019</b>
<b>Bükk, forested site</b>			<b>Bükk, non-forested site</b>		
	$z$	$p$		$z$	$p$
D1 – D1R	-3.01	<b>0.003</b>	D1 – D1R	-4.93	< <b>0.001</b>
D1 – D2	4.46	< <b>0.001</b>		$X^2$	$p$
				15.12	< <b>0.001</b>
				$z$	$p$
			D1 – D2	-1.37	0.170
			D1 – D3	-3.86	< <b>0.001</b>
			D2 – D3	-2.51	<b>0.012</b>



**Table E8** Comparisons of the number of plant species of high conservation importance between habitats (D1: little disturbed dolines and D1R: little disturbed plateau), and among disturbance classes in the dolines (D1: little, D2: medium and D3: high disturbance) using the fitted mixed-effect models. The  $p$  values were corrected with the FDR (false discovery rate) method. Significant differences ( $p \leq 0.05$ ) are indicated by bold  $p$  values

<b>Kras</b>			<b>Mecsek</b>		
	$z$	$p$		$z$	$p$
D1 – D1R	-0.05	0.964	D1 – D1R	-1.59	0.112
	$X^2$	$p$		$X^2$	$p$
	3.50	0.174		2.70	0.260
	$z$	$p$		$z$	$p$
D1 – D2	-1.86	0.186	D1 – D2	-1.54	0.360
D1 – D3	-0.71	0.480	D1 – D3	-1.18	0.360
D2 – D3	1.25	0.318	D2 – D3	0.37	0.712
<b>Bükk, forested site</b>			<b>Bükk, non-forested site</b>		
	$z$	$p$		$z$	$p$
D1 – D1R	-1.69	0.091	D1 – D1R	-2.99	<b>0.003</b>
D1 – D2	1.13	0.259		$X^2$	$p$
				16.23	<b>&lt; 0.001</b>
				$z$	$p$
			D1 – D2	-1.95	<b>0.050</b>
			D1 – D3	-4.03	<b>&lt; 0.001</b>
			D2 – D3	-2.17	<b>0.049</b>