Snowball Search and global quantification of the references

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1 Setup

```
library(bibtex)
library(openalexR)

#library(dplyr)
#library(ggplot2)
#library(knitr)

kp <- bibtex::read.bib("./key-paper.bib")
dois <- sapply(
    kp,
    function(x){
        x$doi
    }
    )
```

2 Searches

2.1 OpenAlex

2.1.1 Setup OpelAnex usage and do snowball serarch

```r
library(ggraph)
```

Loading required package: ggplot2

```r
library(tidygraph)
```

Attaching package: 'tidygraph'

The following object is masked from 'package:stats':

    filter

```r
key_works <- oa_fetch(
    entity = "works",
    doi = dois,
    verbose = FALSE
)

ids <- openalexR:::shorten_oaid(key_works$id)

citing_kp <- lapply(
    ids,
    function(id) {
        oa_fetch(
            entity = "works",
            output = "tibble",
            cites = id,
            verbose = FALSE
        )
    }
)
```

```
Warning in oa_fetch(entity = "works", output = "tibble", cites = id, verbose =
FALSE): No collection found!
```

```r
names(citing_kp) <- ids

cited_by_kp <- lapply(
    ids,
    function(id) {
        oa_fetch(
            entity = "works",
            output = "tibble",
            cited_by = id,
            verbose = FALSE
        )
    }
)
names(cited_by_kp) <- ids

## get the snowball data
snowball <- oa_snowball(
    identifier = ids,
    verbose = FALSE
)

flat_snow <- snowball2df(snowball)
```
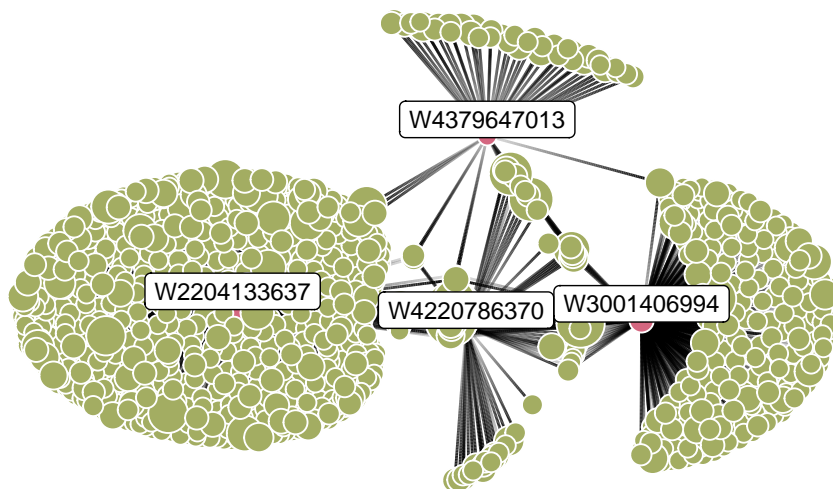
2.1.2 Graph of links between references

```r
ggraph(graph = as_tbl_graph(snowball), layout = "stress") +
    geom_edge_link(aes(alpha = after_stat(index)), show.legend = FALSE) +
    geom_node_point(aes(fill = oa_input, size = cited_by_count), shape = 21, color = "whit
    geom_node_label(aes(filter = oa_input, label = id), nudge_y = 0.2, size = 3) +
    scale_edge_width(range = c(0.1, 1.5), guide = "none") +
    scale_size(range = c(3, 10), guide = "none") +
    scale_fill_manual(values = c("#a3ad62", "#d46780"), na.value = "grey", name = "") +
    theme_graph() +
    theme(
        plot.background = element_rect(fill = "transparent", colour = NA),
        panel.background = element_rect(fill = "transparent", colour = NA),
        legend.position = "bottom"
```

```
    ) +
    guides(fill = "none")
```

Warning: Using the `size` aesthetic in this geom was deprecated in ggplot2 3.4.0.
i Please use `linewidth` in the `default_aes` field and elsewhere instead.

2.1.3 Identification of references with more than one edge

This is the number of connections (`connection_count`)of the paper (`id`)

```
mult_edge <- flat_snow |>
    select(id, connection_count) |>
    filter(connection_count > 1) |>
    arrange(desc(connection_count))

links <- flat_snow |>
    filter(id %in% mult_edge$id)

links |>
    select(id, display_name, publication_year, doi, connection_count) |>
    arrange(desc(connection_count)) |>
    knitr::kable()
```

id	display_name	publication_year	doi	connection_count
W2204393637	Sustainability Transitions Research: Transforming Science and Practice for Societal Change	2017	https://doi.org/10.1146/annurev-environ-102014-021340	72
W3001406994	Transformations to sustainability: combining structural, systemic and enabling approaches	2020	https://doi.org/10.1016/j.cosust.2019.12.004	28
W4220786371	Critical social science perspectives on transformations to sustainability	2022	https://doi.org/10.1016/j.cosust.2022.10116	66
W4379647013	Untangling theories of transformation: Reflections for ocean governance	2023	https://doi.org/10.1016/j.marpol.2023.1057	55
W2520670351	Exploring the governance and politics of transformations towards sustainability	2017	https://doi.org/10.1016/j.eist.2016.09.001	
W2011303397	Resilience and Stability of Ecological Systems	1973	https://doi.org/10.1146/annurev.es.04.1101	
W2020849093	Social transformation in response to global environmental change: A review of emerging concepts	2014	https://doi.org/10.1007/s13280-014-0582-z	
W2096885696	A safe operating space for humanity	2009	https://doi.org/10.1038/461472a	
W2127569725	Resilience Thinking: Integrating Resilience, Adaptability and Transformability	2010	https://doi.org/10.5751/es-03610-150420	
W2127643578	Global environmental change II	2011	https://doi.org/10.1177/0309132511425767	
W2315895902	Sustainability transformations: a resilience perspective	2014	https://doi.org/10.5751/es-06799-190401	
W2790286726	A perspective on radical transformations to sustainability: resistances, movements and alternatives	2018	https://doi.org/10.1007/s11625-018-0543-8	
W2804556255	Transition versus transformation: What's the difference?	2018	https://doi.org/10.1016/j.eist.2017.10.007	
W2883507226	The Dark Side of Transformation: Latent Risks in Contemporary Sustainability Discourse	2018	https://doi.org/10.1111/anti.12405	
W2960049244	Transformations to Sustainability	2019	https://doi.org/10.3390/su11143881	
W4281563038	The Urgency of Transforming Biodiversity Governance	2022	https://doi.org/10.1017/9781108856348.002	
W4362573725	Reframing technology: The evolution from biogas to biomethane in Austria	2023	https://doi.org/10.1016/j.eist.2023.100724	
W1964510407	Adaptation and transformation	2014	https://doi.org/10.1007/s10584-014-1303-0	
W1976459885	ADAPTIVE GOVERNANCE OF SOCIAL-ECOLOGICAL SYSTEMS	2005	https://doi.org/10.1146/annurev.energy.30.0	
W1999175944	Planetary boundaries: Guiding human development on a changing planet	2015	https://doi.org/10.1126/science.1259855	
W2009075240	Caution! Transitions Ahead: Politics, Practice, and Sustainable Transition Management	2007	https://doi.org/10.1068/a39310	

id	display_name	publication_year	doi	connection_count
W2030...	The economics of degrowth	2012	https://doi.org/10.1016/j.ecolecon.2012.08.0...	
W2048...	Action research and participation: roles of researchers in sustainability transitions	2014	https://doi.org/10.1007/s11625-014-0258-4	
W2067...	Engaging with the politics of sustainability transitions	2011	https://doi.org/10.1016/j.eist.2011.02.003	
W2078...	Transformational adaptation when incremental adaptations to climate change are insufficient	2012	https://doi.org/10.1073/pnas.1115521109	
W2099...	Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study	2002	https://doi.org/10.1016/s0048-7333(02)00062-8	
W2156...	Typology of sociotechnical transition pathways	2007	https://doi.org/10.1016/j.respol.2007.01.003	
W2274...	Resilience, Adaptability and Transformability in Social-ecological Systems	2004	https://doi.org/10.5751/es-00650-090205	
W2516...	The politics of sustainability transitions	2016	https://doi.org/10.1080/1523908x.2016.1216...	
W2800...	Is 1.5°C target possible? Exploring the three spheres of transformation	2018	https://doi.org/10.1016/j.cosust.2018.04.010	
W2809...	Enabling agency for social-ecological transformation: a transformation-lab in the Xochimilco social-ecological system	2018	https://doi.org/10.5751/es-10214-230246	
W2901...	Fostering transformative spaces for sustainability in social-ecological systems	2018	https://doi.org/10.5751/es-10607-230432	
W2910...	An agenda for sustainability transitions research: State of the art and future directions	2019	https://doi.org/10.1016/j.eist.2019.01.004	
W2918...	Capitalism in sustainability transitions research: Time for a critical turn?	2020	https://doi.org/10.1016/j.eist.2019.02.005	
W2966...	Sociotechnical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective	2019	https://doi.org/10.1016/j.cosust.2019.06.009	
W3030...	Scaling the impact of sustainability initiatives: a typology of amplification processes	2020	https://doi.org/10.1186/s42854-020-00007-9	
W3036...	Sustainability transformations: socio-political shocks as opportunities for governance transitions	2020	https://doi.org/10.1016/j.gloenvcha.2020.10...	
W3047...	Sustainability Science: Toward a Synthesis	2020	https://doi.org/10.1146/annurev-environ-012420-043621	
W3092...	Capacity to Promote Transformations	2020	https://doi.org/10.21428/2f8d85a02.6bc9d7a...	
W3092...	Pandemic transformations: How and why COVID-19 requires us to rethink development	2021	https://doi.org/10.1016/j.worlddev.2020.105...	
W3108...	A leverage points perspective on social networks to understand sustainability transformations: evidence from Southern Transylvania	2020	https://doi.org/10.1007/s11625-020-00881-z	

id	display_name	publication_year	doi	connection_count
W3129398045	What changes are needed for transformations to a good Anthropocene	2021	https://doi.org/10.1038/s42949-021-00017-x	2
W3136925335	Building bottom-up actor coalitions for transforming complex rural territorial pathways	2021	https://doi.org/10.1016/j.cosust.2021.02.00	2
W3140580253	Science for Transformative Air Quality Policy in Germany and Niger	2021	https://doi.org/10.3390/su13073973	2
W3154787182	Transformation beyond conservation: how critical social science can contribute to a radical new agenda in biodiversity conservation	2021	https://doi.org/10.1016/j.cosust.2021.03.005	2
W3157054384	The migration-sustainability paradox: transformations in mobile worlds	2021	https://doi.org/10.1016/j.cosust.2021.03.013	2
W3159389095	An Overview of the Problems and Prospects for Circular Agriculture in Sustainable Food Systems in the Anthropocene	2021	https://doi.org/10.48130/cas-2021-0003	2
W3163483782	Assessing nature-based solutions for transformative change	2021	https://doi.org/10.1016/j.oneear.2021.04.01	2
W3163293840	Making place-based sustainability initiatives visible in the Brazilian Amazon	2021	https://doi.org/10.1016/j.cosust.2021.03.007	2
W3169157822	The governance of sociotechnical transformations to sustainability	2021	https://doi.org/10.1016/j.cosust.2021.04.010	2
W3185847870	The role of data in transformations to sustainability: a critical research agenda	2021	https://doi.org/10.1016/j.cosust.2021.06.009	2
W3186104796	Transforming matters: sustaining gold lifeways in artisanal and small-scale mining	2021	https://doi.org/10.1016/j.cosust.2021.06.010	2
W3189680882	How to Save a Million Species? Transformative Governance through Prioritization	2022	https://doi.org/10.1017/9781108856348.005	2
W3204411747	Crisis, transformation, and agency: Why are people going back-to-the-land in Greece?	2021	https://doi.org/10.1007/s11625-021-01043-5	2
W4200263675	Exploring the social, ethical, legal, and responsibility dimensions of artificial intelligence for health – a new column in Intelligent Medicine	2022	https://doi.org/10.1016/j.imed.2021.12.002	2
W4200343243	Unlocking the transformative potential of urban food	2021	https://doi.org/10.1038/s42949-021-00041-x	2
W4200483750	Abordagem sistêmica, coalizões e territórios	2021	https://doi.org/10.37370/raizes.2021.v41.73	2
W4205208166	Democratising sustainability transformations: Assessing the transformative potential of democratic practices in environmental governance	2022	https://doi.org/10.1016/j.esg.2021.100131	2
W4221021983	How to swarm? Organizing for sustainable and equitable food systems transformation in a time of crisis	2022	https://doi.org/10.1016/j.gfs.2022.100629	2

id	display_name	publication_year	doi	connection_count
W4281528495	Systems thinking as a paradigm shift for sustainability transformation	2022	https://doi.org/10.1016/j.gloenvcha.2022.10...	
W4294365752	Transformative adaptation and implications for transdisciplinary climate change research	2022	https://doi.org/10.1088/2752-5295/ac8b9d	
W4304822863	Systems transformations in South America: Insights from a transdisciplinary process rooted in Uruguay	2022	https://doi.org/10.3389/fsufs.2022.887034	
W4311654416	Transdisciplinary transformative change: An analysis of some best practices and barriers and the role of critical social science in getting us there	2022	https://doi.org/10.21203/rs.3.rs-2330434/v1	
W4313241558	Turns in sustainability transition studies: Concepts, blind spots and future orientations	2023	https://doi.org/10.1016/j.eist.2022.100686	
W4328120242	Transdisciplinary transformative change: an analysis of some best practices and barriers, and the potential of critical social science in getting us there	2023	https://doi.org/10.1007/s10531-023-02576-0	
W4367316384	Toward a systemic approach to energy transformation in Algeria	2023	https://doi.org/10.1007/s41207-023-00367-1	
W4379231524	Unlocking and accelerating transformations to the SDGs: a review of existing knowledge	2023	https://doi.org/10.1007/s11625-023-01342-z	
W4381432119	Place-based solutions for global social-ecological dilemmas: An analysis of locally grounded, diversified, and cross-scalar initiatives in the Amazon	2023	https://doi.org/10.1016/j.gloenvcha.2023.10...	
W4382133187	How to achieve the net-zero target? Lessons learned from past transformations	2023	https://doi.org/10.1371/journal.pstr.000006...	
W4382623225	Moving beyond agency? Pluralizing structure(s) in sustainability transitions	2023	https://doi.org/10.1016/j.erss.2023.103120	

2.1.4 Identification of Concepts

OpenAlex assigns all works concepts. The concepts are in hirarchical order, ranging from 0 to 3. The higher the number, the more specific the concept. The concepts are assigned to the paper (`id`)

2.1.4.1 Level 0

```r
lapply(
    flat_snow[["concepts"]],
    FUN = function(x) {
        x[["display_name"]][x[["level"]] == 0]
    }
) |>
    unlist() |>
    table() |>
    sort(decreasing = TRUE) |>
    knitr::kable()
```

Var1	Freq
Political science	682
Biology	667
Sociology	566
Economics	556
Business	524
Computer science	469
Geography	361
Philosophy	302
Engineering	294
Physics	181
Chemistry	143
Psychology	138
Environmental science	136
Mathematics	88
Medicine	85
Art	27
Geology	16
History	15
Materials science	8

2.1.4.2 Level 1

```r
lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 1]
    }
) |>
```

```
unlist() |>
table() |>
sort(decreasing = TRUE) |>
knitr::kable()
```

Var1	Freq
Ecology	622
Law	508
Environmental resource management	258
Finance	223
Social science	220
Pedagogy	202
Archaeology	196
Environmental planning	194
Public relations	167
Biochemistry	161
Economic system	159
Artificial intelligence	157
Environmental ethics	140
Epistemology	127
Knowledge management	123
Quantum mechanics	119
Management	118
Management science	106
Process management	95
Operating system	92
Environmental economics	85
Linguistics	85
Economic growth	83
Engineering ethics	80
Economic geography	70
Pathology	67
Marketing	66
Political economy	66
Social psychology	65
Natural resource economics	61
Public administration	58
Industrial organization	56
Programming language	56
Anthropology	50
Machine learning	50

Var1	Freq
Paleontology	41
Civil engineering	39
Electrical engineering	39
Mechanical engineering	39
Neuroscience	39
Thermodynamics	39
Risk analysis (engineering)	38
Regional science	37
Computer security	35
Market economy	29
Microeconomics	28
Psychiatry	28
World Wide Web	27
Cartography	26
Macroeconomics	26
Mathematical analysis	25
Economy	24
Statistics	24
Algorithm	23
Waste management	23
Pure mathematics	22
Computer network	20
Demography	20
Psychotherapist	20
Embedded system	19
Evolutionary biology	16
Structural engineering	16
Positive economics	15
Public economics	15
Development economics	14
Aesthetics	13
Geometry	13
Neoclassical economics	13
Optics	13
Visual arts	13
Law and economics	12
Oceanography	12
Botany	11
Data science	11
Environmental engineering	11
Financial economics	10

Var1	Freq
Communication	9
Database	9
Nursing	9
Agroforestry	8
Forestry	8
Geodesy	8
Humanities	8
Literature	8
Meteorology	8
Systems engineering	8
Telecommunications	8
Genetics	7
Software engineering	7
Water resource management	7
Architectural engineering	6
Data mining	6
Internal medicine	6
Acoustics	5
Agricultural economics	5
Astrobiology	5
International trade	5
Accounting	4
Composite material	4
Developmental psychology	4
Fishery	4
Gender studies	4
Operations management	4
Organic chemistry	4
Physical geography	4
Advertising	3
Agronomy	3
Astronomy	3
Cognitive psychology	3
Combinatorics	3
Econometrics	3
Library science	3
Mathematical economics	3
Petroleum engineering	3
Transport engineering	3
Virology	3
Agricultural science	2

Var1	Freq
Applied psychology	2
Art history	2
Astrophysics	2
Classical mechanics	2
Cognitive science	2
Engineering management	2
Engineering physics	2
Environmental health	2
Financial system	2
Immunology	2
Information retrieval	2
Internet privacy	2
Mathematical physics	2
Media studies	2
Physical chemistry	2
Polymer chemistry	2
Reliability engineering	2
Theology	2
Welfare economics	2
Aerospace engineering	1
Biotechnology	1
Chemical engineering	1
Chromatography	1
Climatology	1
Commerce	1
Computer vision	1
Condensed matter physics	1
Demographic economics	1
Earth science	1
Economic history	1
Endocrinology	1
Environmental protection	1
Food science	1
Geomorphology	1
Geotechnical engineering	1
Gynecology	1
Human–computer interaction	1
Keynesian economics	1
Mathematics education	1
Medical education	1
Nanotechnology	1

Var1	Freq
Natural language processing	1
Nuclear engineering	1
Nuclear physics	1
Operations research	1
Parallel computing	1
Socioeconomics	1
Soil science	1
Theoretical computer science	1

2.1.4.3 Level 2

```
lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 2]
    }
) |>
    unlist() |>
    table() |>
    sort(decreasing = TRUE) |>
    knitr::kable()
```

Var1	Freq
Sustainability	447
Politics	233
Corporate governance	231
Transformative learning	183
Gene	155
Context (archaeology)	134
Sustainable development	134
Agriculture	97
Climate change	94
Agency (philosophy)	72
Perspective (graphical)	67
Process (computing)	67
Action (physics)	60
Alternative medicine	50
Government (linguistics)	45
Adaptation (eye)	38

Var1	Freq
Futures contract	38
Resilience (materials science)	38
Stakeholder	37
Framing (construction)	35
Scale (ratio)	34
Transformational leadership	33
Power (physics)	32
Renewable energy	31
Scholarship	31
Normative	30
Psychological resilience	30
Sociotechnical system	30
Citizen journalism	29
Energy (signal processing)	26
Urban planning	26
Circular economy	25
Order (exchange)	25
Value (mathematics)	25
Work (physics)	25
Anthropocene	24
Conceptual framework	24
Leverage (statistics)	24
Variety (cybernetics)	23
Earth system science	22
Mainstream	22
Production (economics)	22
Psychological intervention	22
Reflexivity	22
State (computer science)	22
Vision	22
Niche	21
Population	20
Set (abstract data type)	19
Economic Justice	18
Diversity (politics)	17
Field (mathematics)	17
Vulnerability (computing)	17
Ecosystem	16
Social change	16
Accountability	15
Biodiversity	15

Var1	Freq
Business model	15
Disease	15
Incentive	15
Interdependence	15
Qualitative research	15
Typology	15
Empirical research	14
Equity (law)	14
Habitat	14
Intermediary	14
Narrative	14
Negotiation	14
Transformation processes	14
China	13
Dynamics (music)	13
Function (biology)	13
Greenhouse gas	13
Resource (disambiguation)	13
Urbanization	13
Cognitive reframing	12
Electricity	12
Nexus (standard)	12
Scope (computer science)	12
Space (punctuation)	12
Status quo	12
Consumption (sociology)	11
Discipline	11
Ecological systems theory	11
Empowerment	11
Key (lock)	11
Metropolitan area	11
Natural resource	11
Operationalization	11
Transdisciplinarity	11
Conceptualization	10
Identity (music)	10
Relevance (law)	10
Stakeholder engagement	10
Technological change	10
Fossil fuel	9
Indigenous	9

Var1	Freq
Innovation system	9
Restructuring	9
Situated	9
Systems thinking	9
Argument (complex analysis)	8
Bridging (networking)	8
Content (measure theory)	8
Entrepreneurship	8
Paradigm shift	8
Social learning	8
System dynamics	8
Tourism	8
Viewpoints	8
German	7
Land use	7
Living lab	7
Quality (philosophy)	7
Software deployment	7
Transparency (behavior)	7
Adaptability	6
Adaptive management	6
Commons	6
Control reconfiguration	6
Credibility	6
Dimension (graph theory)	6
Futures studies	6
General partnership	6
Health care	6
Livestock	6
Pace	6
Perception	6
Position (finance)	6
Scarcity	6
Social capital	6
Structure and agency	6
Supply chain	6
Term (time)	6
Unpacking	6
Action research	5
Ambiguity	5
Architecture	5

Var1	Freq
Biosphere	5
Citizen science	5
Destabilisation	5
Embeddedness	5
Higher education	5
Human settlement	5
Humanity	5
Identification (biology)	5
Institutionalisation	5
Intermediation	5
Legislature	5
Multidisciplinary approach	5
Natural (archaeology)	5
Public health	5
Relation (database)	5
Resistance (ecology)	5
Sanitation	5
Structuring	5
Unintended consequences	5
Amazon rainforest	4
Big data	4
CLARITY	4
Competition (biology)	4
Complex adaptive system	4
Desk	4
Efficient energy use	4
Emerging technologies	4
Environmental justice	4
Experiential learning	4
Financial crisis	4
Flexibility (engineering)	4
Focus group	4
Food waste	4
Human systems engineering	4
Index (typography)	4
Institutional change	4
Interpretation (philosophy)	4
Intervention (counseling)	4
Latin Americans	4
Legislation	4
Lens (geology)	4

Var1	Freq
Local government	4
Meaning (existential)	4
Modernization theory	4
Nature versus nurture	4
Novelty	4
Openness to experience	4
Participatory action research	4
Plural	4
Pluralism (philosophy)	4
Poverty	4
Praxis	4
Scrutiny	4
Special education	4
Strengths and weaknesses	4
Theme (computing)	4
Underpinning	4
Water supply	4
Affect (linguistics)	3
Anthropocentrism	3
Anticipation (artificial intelligence)	3
Autonomy	3
Biofuel	3
Blueprint	3
Boundary (topology)	3
Capacity building	3
Coherence (philosophical gambling strategy)	3
Conflict transformation	3
Conversation	3
Coproduction	3
Creativity	3
Deforestation (computer science)	3
Dependency (UML)	3
Development (topology)	3
Dialectic	3
Distribution (mathematics)	3
Diversification (marketing strategy)	3
Element (criminal law)	3
Empirical evidence	3
Energy consumption	3
Environmental law	3
Exploit	3

Var1	Freq
Extant taxon	3
Face (sociological concept)	3
Financial intermediary	3
Focus (optics)	3
Formative assessment	3
Frame (networking)	3
Green infrastructure	3
Heuristics	3
Inclusion (mineral)	3
Injustice	3
Institutional theory	3
Internet of Things	3
Knowledge production	3
Lagging	3
Logit	3
Maladaptation	3
Mindset	3
Neutrality	3
Outbreak	3
Path dependence	3
Phase (matter)	3
Phenomenon	3
Policy analysis	3
Premise	3
Procurement	3
Product (mathematics)	3
Profit (economics)	3
Public engagement	3
Public policy	3
Realm	3
Reciprocity (cultural anthropology)	3
Scaling	3
Scenario planning	3
Service (business)	3
Social dynamics	3
Social system	3
Sociocultural evolution	3
Sociology of scientific knowledge	3
Spatial planning	3
Tanzania	3
Theory of change	3

Var1	Freq
Thriving	3
Tipping point (physics)	3
Water resources	3
Acknowledgement	2
Action plan	2
Air quality index	2
Archetype	2
Best practice	2
Bibliometrics	2
Business ethics	2
Capital (architecture)	2
Catalysis	2
Character (mathematics)	2
Clean energy	2
Coevolution	2
Commodification	2
Community engagement	2
Comparative advantage	2
Comparative case	2
Competence (human resources)	2
Competitive advantage	2
Component (thermodynamics)	2
Composite number	2
Conceptual model	2
Conservation biology	2
Consistency (knowledge bases)	2
Consolidation (business)	2
Construct (python library)	2
CONTEST	2
Control (management)	2
Corporate social responsibility	2
Critical theory	2
Cybernetics	2
Dance	2
Demand side	2
Demographics	2
Dependability	2
Directive	2
Disaster risk reduction	2
Disconnection	2
Downstream (manufacturing)	2

Var1	Freq
Earth (classical element)	2
Ecological psychology	2
Emerging markets	2
Engineering design process	2
Environmental education	2
Environmental impact assessment	2
Environmental policy	2
Environmental stewardship	2
Excellence	2
Explanatory power	2
Exploratory research	2
Facilitation	2
Fishing	2
Food packaging	2
Food processing	2
Fragmentation (computing)	2
Globalization	2
Globe	2
GRASP	2
Grazing	2
Greening	2
Grid	2
Heuristic	2
Ideal (ethics)	2
Idealism	2
Impact assessment	2
Industrial policy	2
Industrial society	2
Industrialisation	2
Inequality	2
Information and Communications Technology	2
Ingenuity	2
Interpersonal ties	2
Intersectionality	2
Irrigation	2
Knowledge base	2
Language change	2
Leapfrogging	2
Local community	2
Macro	2
Malaria	2

Var1	Freq
Management system	2
Marketing management	2
Mediation	2
MEDLINE	2
Metaphor	2
Modal	2
Neighbourhood (mathematics)	2
Newspaper	2
Niche construction	2
Outcome (game theory)	2
Parallels	2
Participatory planning	2
Payment	2
Plan (archaeology)	2
Planet	2
Plea	2
Popularity	2
Pragmatism	2
Prioritization	2
Productivity	2
Prosperity	2
Public interest	2
Public transport	2
Rationality	2
Refugee	2
Reputation	2
Resource efficiency	2
Revenue	2
Rigour	2
Risk management	2
Safeguarding	2
Salience (neuroscience)	2
Salient	2
Science education	2
Science policy	2
Shock (circulatory)	2
Social group	2
Social media	2
Stock (firearms)	2
Strategic planning	2
Subsidy	2

Var1	Freq
Surface runoff	2
Surprise	2
Systems theory	2
Temporality	2
The arts	2
The Renaissance	2
Tragedy (event)	2
Trap (plumbing)	2
Treaty	2
TRIPS architecture	2
Urban landscape	2
Utopia	2
Value creation	2
Welfare	2
Work in process	2
Abstraction	1
Acceleration	1
Agent-based model	1
Alliance	1
Analogy	1
Analytic hierarchy process	1
Aotearoa	1
Appeal	1
Appropriation	1
Archipelago	1
Argumentation theory	1
Artificial neural network	1
Attractor	1
Autoethnography	1
Balanced scorecard	1
Baltic sea	1
Basic income	1
Bespoke	1
Biobank	1
Biodegradable plastic	1
Biogas	1
Biologist	1
Blame	1
Blank	1
Block (permutation group theory)	1
Blockchain	1

Var1	Freq
Bounded function	1
Bounded rationality	1
Bricolage	1
Bridge (graph theory)	1
Business case	1
Business ecosystem	1
Butterfly	1
Capability approach	1
Cape	1
Car sharing	1
Causal model	1
Causality (physics)	1
Ceiling (cloud)	1
Centrality	1
Chaotic	1
Chart	1
Chemical industry	1
Christian ministry	1
Citation	1
Classifier (UML)	1
Clean technology	1
Closing (real estate)	1
Clothing	1
Cloud computing	1
Co-creation	1
Coal	1
Coding (social sciences)	1
Cognition	1
Collaborative learning	1
Commercialism	1
Commodity	1
Comparability	1
Complex system	1
Complexity management	1
Compromise	1
Computable general equilibrium	1
Conflation	1
Conflict resolution	1
Consciousness	1
Consciousness raising	1
Constellation	1

Var1	Freq
Constitution	1
Content analysis	1
Contradiction	1
Core (optical fiber)	1
Craft	1
Creative destruction	1
Crisis management	1
Crisis response	1
Critical infrastructure	1
Critical reflection	1
Criticism	1
Crop protection	1
Cultural psychology	1
Cultural values	1
Curiosity	1
Curriculum	1
Data-driven	1
Decentralization	1
Decision tree	1
Declaration	1
Developing country	1
Dialog box	1
Dialogical self	1
Dichotomy	1
Diffusion	1
Dilemma	1
Disadvantaged	1
Discrete choice	1
Disruptive innovation	1
Distance decay	1
Divergence (linguistics)	1
Division of labour	1
Documentation	1
Domestic market	1
DPSIR	1
Drone	1
Duration (music)	1
Dynamic capabilities	1
Dynamism	1
E-commerce	1
Ecological crisis	1

Var1	Freq
Ecological engineering	1
Economic recovery	1
Economic rent	1
Electronic waste	1
Embodied cognition	1
Enabling	1
Energy conservation	1
Energy demand	1
Energy sector	1
Enforcement	1
Environmental crisis	1
Environmental restoration	1
Estonian	1
European union	1
Event (particle physics)	1
Everyday life	1
Evolutionary economics	1
Evolutionary psychology	1
Evolutionary theory	1
Experiential knowledge	1
Explanatory model	1
Exposition (narrative)	1
Expression (computer science)	1
Extended producer responsibility	1
Externality	1
Extinction (optical mineralogy)	1
Facilitator	1
Factory (object-oriented programming)	1
Fidelity	1
Financialization	1
Fish	1
Flemish	1
Flood myth	1
Flourishing	1
Foregrounding	1
Forest management	1
Fragility	1
Frontier	1
Fuel cells	1
Genetic testing	1
Germination	1

Var1	Freq
Glass ceiling	1
Glyphosate	1
Gold mining	1
Goods and services	1
Graph	1
Great Rift	1
Gross domestic product	1
Groundwater	1
Honor	1
Horizontal and vertical	1
Human capital	1
Human geography	1
Human resources	1
Human values	1
Hydropower	1
Hygiene	1
Hyperparameter	1
Ideal type	1
Ignorance	1
Image (mathematics)	1
Immediacy	1
Impossibility	1
Individual mobility	1
Individualism	1
Industrial and production engineering	1
Inertia	1
Informal sector	1
Information flow	1
Information technology	1
Innovation diffusion	1
Innovation management	1
Institution	1
Institutional economics	1
Institutional logic	1
Integrated pest management	1
Intellectual property	1
Interconnectivity	1
Intercropping	1
Interdisciplinarity	1
International Action	1
Interpersonal communication	1

Var1	Freq
Intersection (aeronautics)	1
Jargon	1
Knowledge engineering	1
Knowledge-based systems	1
Landscape design	1
Lead (geology)	1
Legal research	1
Liberalization	1
Life course approach	1
Lift (data mining)	1
Linearity	1
Listing (finance)	1
Lithium (medication)	1
Living systems	1
Local Development	1
Lock (firearm)	1
Looming	1
Marine conservation	1
Marine research	1
Marine spatial planning	1
Matching (statistics)	1
Material flow	1
Material flow analysis	1
Materialism	1
Materiality (auditing)	1
Maturity (psychological)	1
Maya	1
Measure (data warehouse)	1
Medical equipment	1
Membrane	1
Merge (version control)	1
Mesoamerica	1
Mesopotamia	1
Methodological individualism	1
Miami	1
Microfoundations	1
Miller	1
Mindfulness	1
Modalities	1
Mode (computer interface)	1
Modernity	1

Var1	Freq
Moral imperative	1
Moral responsibility	1
Movement (music)	1
Multinomial logistic regression	1
Multitude	1
Musical	1
National innovation system	1
Natural disaster	1
Natural gas	1
Natural hazard	1
Neglect	1
Neoliberalism (international relations)	1
Network effect	1
Niche market	1
Norm (philosophy)	1
Normal science	1
North west	1
Nothing	1
Nuclear power	1
Nuclear power plant	1
Objectivity (philosophy)	1
Open innovation	1
Opportunism	1
Optimism	1
Orthodoxy	1
Outreach	1
Passenger transport	1
Path (computing)	1
Peasant	1
Peninsula	1
Period (music)	1
Personality	1
Photovoltaic system	1
Pluvial	1
Point (geometry)	1
Policy Sciences	1
Pollution	1
Pooling	1
Port (circuit theory)	1
Portfolio	1
Posthumanism	1

Var1	Freq
Postmodernism	1
Practice theory	1
Precipitation	1
Predictive maintenance	1
Preference	1
Presumption	1
Private sector	1
Professionalization	1
Profitability index	1
Pronoun	1
Property (philosophy)	1
Provisioning	1
Prudence	1
Psychosocial	1
Public participation	1
Public service	1
Public space	1
Publishing	1
Punctuated equilibrium	1
Qualitative property	1
Rainwater harvesting	1
Ranking (information retrieval)	1
Raw material	1
Reading (process)	1
Realism	1
Redress	1
Reductionism	1
Redundancy (engineering)	1
Reference model	1
Relocation	1
Reproduction	1
Resource allocation	1
Responsible Research and Innovation	1
Restoration ecology	1
Reuse	1
Rhetoric	1
Rhythm	1
Rope	1
Rural area	1
Sample (material)	1
Sanctions	1

Var1	Freq
Scalability	1
Scheme (mathematics)	1
Secondary sector of the economy	1
Sect	1
Selection (genetic algorithm)	1
Sequence (biology)	1
Skills management	1
Smart grid	1
Social business	1
Social connectedness	1
Social equality	1
Social impact assessment	1
Social innovation	1
Social institution	1
Social justice	1
Social marketing	1
Social mobility	1
Social relation	1
Social responsibility	1
Social security	1
Social theory	1
Social work	1
Socioeconomic development	1
Software	1
Solar energy	1
sort	1
SPARK (programming language)	1
Spatial ecology	1
Spatial heterogeneity	1
Spatial organization	1
Spatial variability	1
Special section	1
SPHERES	1
Stability (learning theory)	1
Structural equation modeling	1
Structuration theory	1
Subject (documents)	1
Subjectification	1
Substitution (logic)	1
Summit	1
Superordinate goals	1

Var1	Freq
Support vector machine	1
Swarm behaviour	1
Tariff	1
Task (project management)	1
Teaching method	1
Technology policy	1
Temporalities	1
Textile	1
The Internet	1
Thematic map	1
Theory of the firm	1
Thermal	1
Timeline	1
Toolbox	1
Top-down and bottom-up design	1
Traceability	1
Tracing	1
Tracking (education)	1
Trajectory	1
Transaction cost	1
Transitive relation	1
Transport system	1
Travel behavior	1
Trilogy	1
Trojan horse	1
Turbine	1
Unit (ring theory)	1
Urban agglomeration	1
Usability	1
Valuation (finance)	1
Value proposition	1
Variable (mathematics)	1
Variables	1
Vegetation (pathology)	1
Virtue	1
Warning system	1
Warrant	1
Wastewater	1
Water diversion	1
Water energy	1
Water quality	1

Var1	Freq
Watershed	1
Watson	1
West germany	1
West virginia	1
Wetland	1
Wildlife	1
Wildness	1
Wind power	1
Window (computing)	1
Wine	1
Wonder	1
Workforce	1
Zoning	1

2.1.4.4 Level 3

```
lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 3]
    }
) |>
    unlist() |>
    table() |>
    sort(decreasing = TRUE) |>
    knitr::kable()
```

Var1	Freq
Transition (genetics)	111
Transition management (governance)	54
Food security	50
Panacea (medicine)	49
Social sustainability	47
Transformation (genetics)	40
Sustainability organizations	30
Environmental governance	22
Sustainable agriculture	22
Grassroots	20
Democracy	19

Var1	Freq
Legitimacy	19
Civil society	15
Collective action	15
Infectious disease (medical specialty)	15
Livelihood	15
Climate governance	13
Urban sustainability	13
Adaptive capacity	12
Agroecology	11
Ecosystem services	10
Social transformation	10
Urban resilience	10
Stewardship (theology)	9
Climate change adaptation	8
Energy system	8
Political ecology	8
Technocracy	8
Climate change mitigation	7
Energy policy	7
Environmental change	7
Multi-level governance	7
Promotion (chess)	7
Sustainable consumption	7
Thematic analysis	7
Agrarian society	6
Landscape ecology	6
Backcasting	5
Deliberation	5
Ecological niche	5
Originality	5
Solidarity	5
Sustainable business	5
Capitalism	4
Collaborative governance	4
Constructive	4
Degrowth	4
Dominance (genetics)	4
Geopolitics	4
Global governance	4
Hegemony	4
Investment (military)	4

Var1	Freq
Mainstreaming	4
Planetary boundaries	4
Social movement	4
Socioeconomic status	4
Through-the-lens metering	4
Urban density	4
2019-20 coronavirus outbreak	3
Boundary object	3
Emancipation	3
Environmental politics	3
Global warming	3
Health policy	3
Ideology	3
Network governance	3
Opposition (politics)	3
Pastoralism	3
Political economy of climate change	3
Product-service system	3
Smart city	3
Social network analysis	3
Sustainable energy	3
Technological innovation system	3
Transferability	3
Value chain	3
Articulation (sociology)	2
Beijing	2
Biodiversity conservation	2
Business process	2
Carbon fibers	2
Causal loop diagram	2
Citizenship	2
Climate justice	2
Climate policy	2
Collective identity	2
Conservation psychology	2
Convention on Biological Diversity	2
Corporate sustainability	2
Destinations	2
Downscaling	2
Ecological economics	2
Ecological footprint	2

Var1	Freq
Ecological modernization	2
Ecological resilience	2
Ecosystem-based management	2
Electronic business	2
Elite	2
Energy law	2
Energy security	2
Global change	2
Global value chain	2
Health promotion	2
Knowledge creation	2
Las vegas	2
Legitimation	2
Natural resource management	2
Phenotype	2
Phoenix	2
Polity	2
Project governance	2
Qualitative analysis	2
Rebound effect (conservation)	2
Regime shift	2
Regulatory state	2
Representation (politics)	2
Scopus	2
Settlement (finance)	2
Social identity theory	2
Social network (sociolinguistics)	2
Socio-ecological system	2
Stakeholder analysis	2
Stakeholder theory	2
Stormwater	2
Sustainable Agriculture Innovation Network	2
Sustainable production	2
Sustainable transport	2
Sustainable Value	2
Systemic risk	2
Threatened species	2
Transnational governance	2
Urban ecosystem	2
Urbanism	2
Value network	2

Var1	Freq
Water scarcity	2
Welfare state	2
Agribusiness	1
Agricultural biodiversity	1
Agricultural diversification	1
Agricultural productivity	1
Aquaculture	1
Aquifer	1
Austerity	1
Behaviour change	1
Betweenness centrality	1
Big Five personality traits	1
Biodiesel	1
Bioenergy	1
Biome	1
Bioproducts	1
Biorefinery	1
Bureaucracy	1
Business analysis	1
Business value	1
Carbon footprint	1
Chimera (genetics)	1
Choreography	1
Citation analysis	1
Climate Finance	1
Climate model	1
Climate risk	1
Climate science	1
Community forestry	1
Community resilience	1
Conditionality	1
Conservation science	1
Contextualization	1
Cooperative learning	1
Critical realism (philosophy of perception)	1
Cultural geography	1
Desalination	1
Distributive justice	1
Dormancy	1
Duopoly	1
Eco-innovation	1

Var1	Freq
Economic governance	1
Economic interventionism	1
Economic shortage	1
Ecosystem management	1
Education for sustainable development	1
Egalitarianism	1
Electricity generation	1
Electrification	1
Energy engineering	1
Energy intensity	1
Energy management	1
Energy planning	1
Energy storage	1
Energy supply	1
Environmental management system	1
Environmental Sustainability Index	1
Environmentalism	1
Epistemic virtue	1
Erasmus+	1
Exploitation of natural resources	1
Extreme weather	1
Fashion industry	1
Fast fashion	1
Fishing industry	1
Food sector	1
Fukushima Nuclear Accident	1
Global health	1
Governmentality	1
Green economy	1
Health equity	1
Health security	1
Healthcare system	1
Historical geography	1
Human genetics	1
Hydrogen fuel	1
Industrial ecology	1
Integrated water resources management	1
Intergenerational equity	1
Intrapersonal communication	1
Ionic liquid	1
Knowledge integration	1

Var1	Freq
Kyoto Protocol	1
Land cover	1
Land grabbing	1
Land management	1
Land use, land-use change and forestry	1
Learning sciences	1
Legal realism	1
Life-cycle assessment	1
Linkage (software)	1
Mains electricity	1
Marine protected area	1
Marketization	1
Medical genetics	1
Millennium Development Goals	1
Modal shift	1
New england	1
Non-renewable resource	1
Normative social influence	1
Nuclear disaster	1
Orchestration	1
Organic farming	1
Overfishing	1
Overgrazing	1
Photovoltaics	1
Plasmodium falciparum	1
Population growth	1
Project commissioning	1
Prosumer	1
Quality assurance	1
Random graph	1
Redistribution (election)	1
Relationship marketing	1
Renewable fuels	1
Requirements engineering	1
Resource curse	1
Resource recovery	1
Return on marketing investment	1
Right to the city	1
Risk governance	1
Risk perception	1
Rurality	1

Var1	Freq
Seagrass	1
Service provider	1
Social activism	1
Social conflict	1
Social determinants of health	1
Social injustice	1
Social reproduction	1
Social vulnerability	1
Sovereignty	1
Strategic environmental assessment	1
Strategic financial management	1
Supply chain management	1
Sustainability reporting	1
Sustainable design	1
Sustainable management	1
Sustainable society	1
Sustainable tourism	1
Traditional knowledge	1
Transcription factor	1
Urban agriculture	1
Urban climate	1
Urban design	1
Urban greening	1
Urban politics	1
Virtue ethics	1
Vitalism	1
Water infrastructure	1
Water sector	1
Welfare reform	1