Changes in social connection in a government research network

Institute for Sustainable Futures for
New South Wales Office of Environment and Heritage

About the authors

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Introduction

Social network analysis (SNA) is an approach that allows quantitative analysis and qualitative insights into interactions between individuals or nodes (Cunningham *et al*., 2014). Metrics such as betweeness and key players can be calculated to identify nodes with potential to reach critical nodes in the network.

Longitudinal SNA explores the development of a network over time, providing insight into the development of the network and extent to which relationships change between participants. For longitudinal SNA to achieve its objectives, it must be undertaken at intervals from inception of a project. This allows changes in the social network to be identified so relationships and collaborations can be nourished as needed. To measure changes in a network efficacy over time, variables can be calculated including average degree (average number of ties in the network), density (total number of connections divided by the total number of possible connections), fragmentation (lack of connectivity), closure (the likelihood that a friend of my friend is likely to be my friend) and diameter (number of steps to reach all nodes in network).

In this project, SNA was used to track changes in connections between individuals from NSW Office of Environment and Heritage (OEH) with expertise or experience in the alpine region of NSW. SNA was used to visualise connections of OEH staff over three meetings held in 2017 and 2018 and:

- explore changes in strength of connection between individuals over the three meetings (ALPINE network: July 2017, November 2017, June 2018)
- identify individuals from whom information about the alpine region was sought (SEEK network: November 2017, June 2018)
- identify individuals who others share information about the alpine region with (SHARE network: November 2017, June 2018).

Method

In 2017, a list was created of staff from NSW Office of Environment and Heritage (OEH) with experience or expertise in the alpine region. The 59 staff on the list were invited to a meeting in Canberra on 25 July 2017 to discuss an OEH program for alpine research. Thirty OEH staff attended. Before the meeting started, attendees were given the list of 59 names and asked to rank their connection to each individual in the network as none (0), weak (1), moderate (2) or strong (3). The strength of connection was not defined by the researchers and was left to the interpretation of respondents.

In November 2017, 18 OEH staff attended a second meeting in Queanbeyan; 16 people who attended the first meeting and two people who were new to the network. Those who attended were given a list of 61 people and asked to rank their connection to each individual. The list included 59 names from the previous list (N1-N59) and two additional names (N60, N61) of people who were invited to the second meeting.

In June 2018, 26 OEH staff attended a third meeting and given a list of 85 names which included:

- 61 names from November 2017 (N1-N61)
- two names (N75, N76) added because they responded by email in November 2017 (but did not attend that meeting)
- seven names (N66, N77, N78, N79, N80, N82, N94) nominated in November 2017 as part of the ALPINE network
- 10 names because they were invited to the meeting in June 2018 (two of these people were listed in the SEEK or SHARE networks, N74, N95)
- four names (N62, N63, N72, N73) added from the SHARE network
- one name (N65) added from the SEEK network.

Before the meetings started, those who attended were asked to rank their connections to the people in the supplied lists (n=59 in July 2017; n=61 in November 2017, n=85 in June 2018). Therefore, responses reflect the connections of individuals prior to the meetings.

After the first two meetings, those who attended were asked for feedback via an online survey. As part of the feedback, respondents were asked how many new people they met at each meeting.

In November 2017 and June 2018, respondents were also asked to name three people who they sought information about the alpine region from (SEEK network) and three people who they shared information about the alpine region with (SHARE network).

The networks were treated as unique networks, i.e. ALPINE, SEEK and SHARE networks. Individuals were numbered sequentially so an individual is represented by the same number in all networks. In the analyses, individuals were categorised as:

- **Attend - respond**: the individual attended the meeting and provided data
- **Attend** – **no response**: the individual attended the meeting but did not provide data
- **Did not attend – email response**: the individual did not attend the meeting but provided data by email
- **Did not attend – no response**: the individual did not attend the meeting or provide data

- **Not in this time period – email response:** the individual was not identified as part of the network at that time period but provided an email response. The data was included in the analysis
- **Not in this time period – no response**: the individual was not identified as part of the network at that time period (and analysed as missing values for that time period).

At the end of the three meetings, the ALPINE network was bound to the total number of participants from every time period (n=87), the SEEK network was bound to 124 participants, and the SHARE network was bound to 124. The data were used to create a symmetric-directed matrix so networks could be mapped and analysed. Analyses and visualisations were run in UCINet (Borgatti *et al*., 2002) and Netdraw (Borgatti, 2006). The visualisation layout uses geodesic distance to position the nodes which forces nodes with similar characteristics together, i.e. those who were nominated by the same people or have similar structural positions are forced together.

The UCINet Multiple Cohesion Measures (Borgatti *et al*., 2002) were calculated to provide insights into the networks. Average degree, density, fragmentation, closure and diameter were calculated so networks could be compared over time.

Key players (diffuse) were calculated using the key player problem 1 algorithm (Borgatti, 2006) which measures the nodes with the most and strongest connections in the network. Individual key player diffuse algorithms were run for each network – ALPINE, SEEK and SHARE.

Results

ALPINE network

In July 2017, 29 individuals ranked their connections to a supplied list of 59 individuals. There were 28 responses at the meeting and one response after the meeting (by email from an individual who did not attend) (Table 1).

In November 2017, 29 individuals ranked their connections to a supplied list of 61 individuals (Table 1). The 29 individuals were:

- eighteen individuals who attended the meeting on 1 November (including two individuals who did not attend the first meeting but were added to the network list in November 2017)
- nine individuals who didn't attend the meeting, but were listed on the original list of 59 individuals and provided data after the meeting
- two individuals who did not attend either meeting, were not in the network list, but were sent the list from someone in the network and provided data.

In June 2018, a total of 26 individuals ranked their connection to a supplied list of 85 individuals. All individuals who responded were listed on the supplied list (Table 1).

The ALPINE networks were visualised for the bound network for July 2017 (Figure 1), November 2017 (Figure 2) and June 2018 (Figure 3). All nodes (i.e. attend, no attend, not in this time period, etc) were visualised for each time period. The node size in the visualisation reflects the total number and strength of connections, i.e. the sum of the strength of the nominated connections. For example, a node with one 'strong' connection (1 node x 3) is the same size as a node with three 'weak' connections (3 nodes x 1). Isolates were nodes that did not respond at that time period nor were they nominated by another node in that network. They appear on the left of the visualisations.

Response rate in the ALPINE network declined from 33.3% to 29.8% (Table 1). Response rate affects multiple cohesion measures so the ALPINE network was bound after June 2018 to ensure results were robust. The network was bound to 87 internal nodes for the three time periods: 5 nodes from Heritage, 45 from NPWS, 10 from Regional Operations, and 27 from Science (Table 2).

The total number of ties increased over time: from 784 in July 2017, to 902 in November 2017 and to 1199 by June 2018.

Table 1. Number of participants in each time period, response rate and participation

	Jul 2017	Nov 2017	Jun 2018
Names on supplied network list	59	61	85
Attend - response	28	18	26
Not attend – email response	1	9	0
Not in this time period – email response	0	2	0
TOTAL RESPONSES	**29**	**29**	**26**
Attend - no response	2	0	0
Not attend – no response	30	34	61
Not in this time period – no response	26	24	0
TOTAL in ALPINE network	**87**	**87**	**87**
Response rate (percent)	33.3	33.3	29.8

Table 2. Number and category of participants in the ALPINE network

Category (Attribute)	ALPINE
OEH – Heritage (D1)	5
OEH – Natl Parks & Wildlife Service (NPWS) (D2)	45
OEH – Regional Operations (D3)	10
OEH – Science (D4)	27

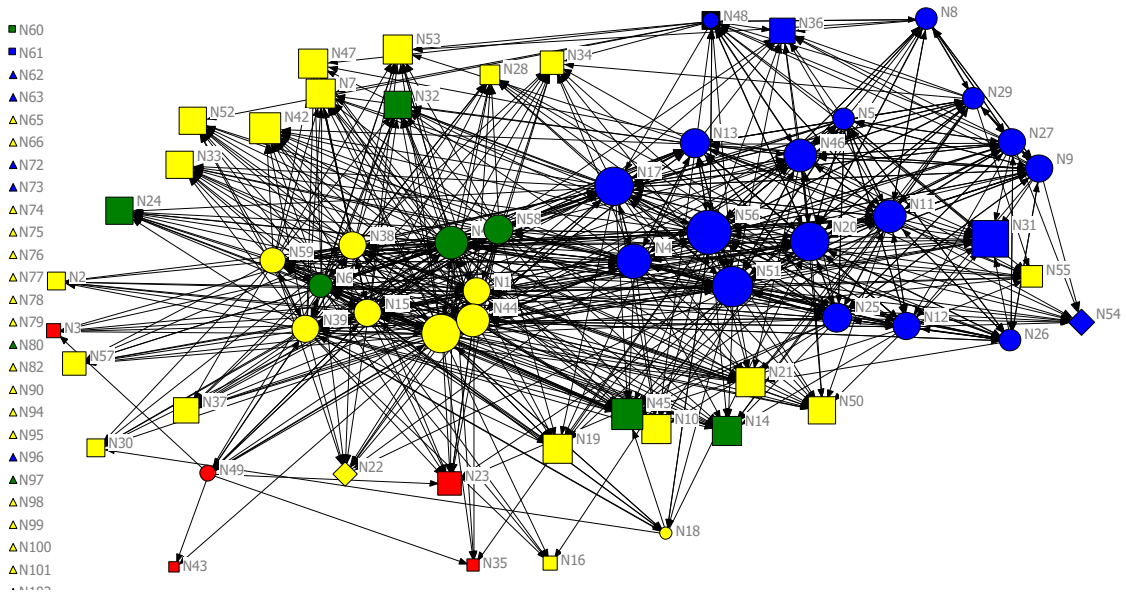

Figure 1. Visualisation of ALPINE network (July 2017). Node colour represents OEH Division/ Group: Red = Heritage (D1)**;** Yellow = NPWS (D2)**;** Green = Regional Operations (D3); Blue = Science (D4). Shape of nodes represent attendance: circle = attended and responded; square = did not attend; square with circle = email response (did not attend); diamond = attended with no response; triangle = not in this time period; plus = email response but not in this time period.

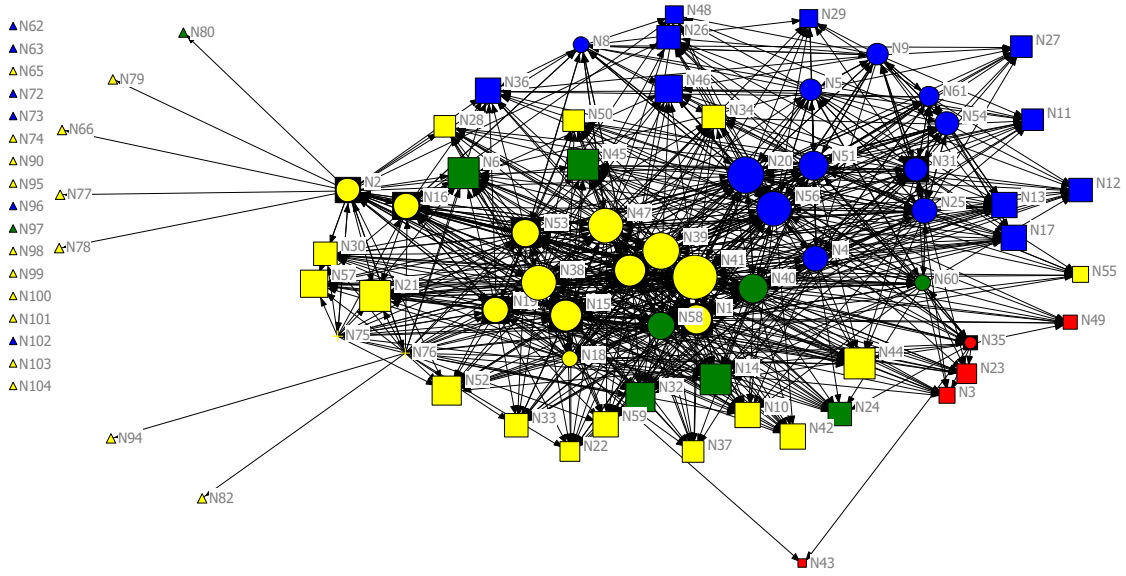

Figure 2. Visualisation of ALPINE network (November 2017). Colour of nodes represent OEH Division/ Group. Red = Heritage (D1)**;** Yellow = NPWS (D2)**;** Green = Regional Operations (D3)**;** Blue = Science (D4). Node shape represent attendance at the meeting: circle = attended and responded; square = did not

attend; square with circle = email response (did not attend); diamond = attended with no response; triangle = not in this time period; plus = email response but not in this time period.

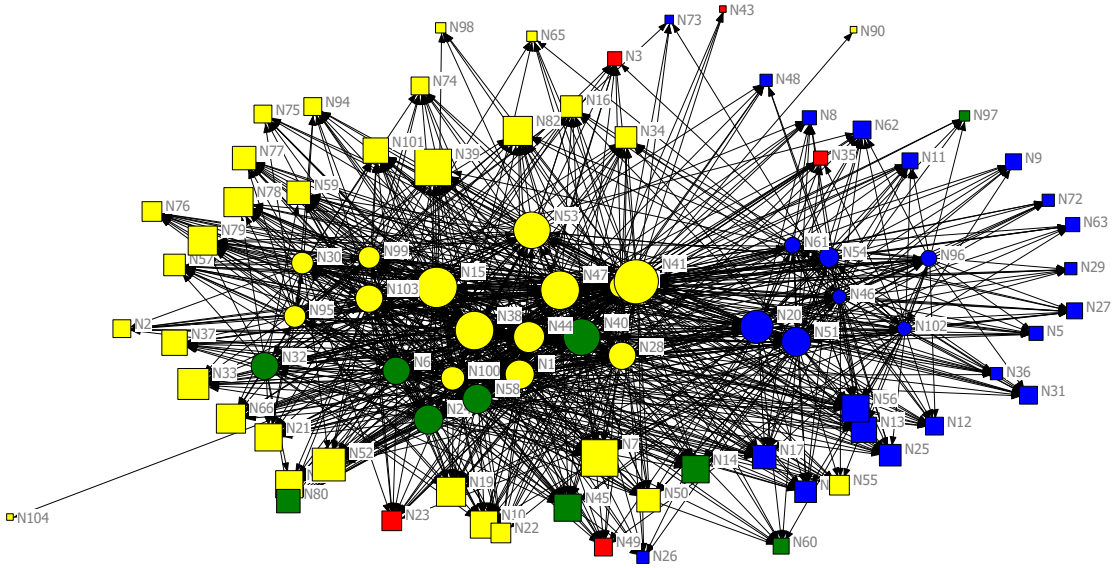

Figure 3. Visualisation of ALPINE network (June 2018). Node colour represents OEH Division/ Group. Red = Heritage (D1)**;** Yellow = NPWS (D2)**;** Green = Regional Operations (D3)**;** Blue = Science (D4). Shape of node represents attendance at the meeting: circle = attended and responded; square = did not attend or respond; square with circle = email response (did not attend); diamond = attended with no response; triangle = not in this time period and no response; plus = not in this time period and email response.

Betweeness for ALPINE network

The UCINet Freemans betweenness (Freeman, 1979) is a node centrality measure that includes degree and closeness. It was calculated for the ALPINE Network for each time period (Table 3). In July 2017, managers (N56 from Science, N41 from NPWS) had the highest betweenness scores in the network. In November 2017, another manager from NPWS (N2) had the highest betweenness score at that time period and at any time period. However, a manager from NPWS (N41) and knowledge broker from Science (N20) also had high betweenness scores. By June 2018, the manager from NPWS (N41) again achieved the highest betweeness score.

Table 3. Betweeness score for nodes in the ALPINE network

Meeting	Node	Betweeness	Division/ Group
July 2017	N56	117	Science
	N41	113	NPWS
	N51	92	Science
	N17	68	Science
	N20	64	Science
	N40	62	Regional Ops
	N44	59	NPWS
November 2017	N2	255	NPWS
	N41	128	NPWS
	N20	100	Science
	N56	99	Science
	N1	64	NPWS
	N47	58	NPWS

June 2018	N41	234	NPWS
	N47	95	NPWS
	N20	70	Science
	N40	59	Regional Ops
	N51	54	Science
	N15	52	NPWS

Multiple Cohesion Measures for ALPINE network

Average degree is the average number of links in the network. The average degree for the ALPINE network increased over time. In July 2017, the average degree indicated that, on average, each individual had nine connections. By November 2017, the average degree had increased to 10 and, by July 2018, to 13 (Table 4).

Density is the total number of connections divided by the total number of possible connections in the network. The density of the ALPINE network increased between July 2017 (0.11), November 2017 (0.12) and June 2018 (0.16) (Table 4). This indicates that individuals in the ALPINE network built connections with more individuals in the network over time.

Fragmentation measures the lack of connectivity in the network. The more fragmented the network, the more vulnerable it is to change. The fragmentation for the ALPINE network decreased from July 2017 (0.78) to November 2017 (0.73) and July 2018 (0.70) (Table 4) reflecting a slight decrease in fragmentation – and better connection - with time.

Closure measures the degree to which 'the friend of my friend is likely to be my friend.' Network theory considers nodes (single nodes), dyads (two nodes) and triads (three nodes). Closure counts the number of triads divided by two. Closure of the ALPINE network remained similar throughout the project (Table 4) indicating the ALPINE network remained closed.

Diameter estimates the number of steps to reach everyone in the network, i.e. 'Bacon's Law' and 'six degrees of separation' (Cunningham *et al*., 2017). The diameter of the network increased from July 2017 (diameter = 3, i.e. minimum of three steps required to get through the network) to November 2017 (diameter = 5, i.e. minimum of five steps required to get through the network) and decreased to the original size by July 2018 (diameter = 3) (Table 4). This indicates that all individuals in the major component of the ALPINE network could be reached in three to five steps throughout the project.

Table 4. Multiple Cohesion Measure Metrics for the ALPINE network over time

Metrics	Jul 2017	Nov 2017	Jun 2018
Average degree	8.98	10.37	13.76
Density	0.11	0.12	0.16
Fragmentation	0.78	0.73	0.70
Closure	0.65	0.65	0.67
Diameter	3	5	3

Key players in the ALPINE network

In July 2017, the 15 key players in the ALPINE network included managers from Regional Operations (N40), NPWS (N41, N74, N75, N82) and Science (N62). Key players also included a

ranger (N78) business manager (N77), project officers (N79, N94), environmental liaison, data and management officers (N65, N76, N95) from NPWS, as well as an economist from Regional Operations (N97) and a scientist from Science (N61). A combination of any of the three key players listed across each row in Table 5 could reach over half (69.05%) of the network.

In November 2017, the 19 key players in the ALPINE network were managers and team leaders from NPWS (N2, N39, N41, N74, N75, N76) and Science (N56, N72, N96). They also included a ranger (N104), Discovery Coordinator (N99), Indigenous liaison officer (N98) and environmental management officer and data officer (N65, N76) from NPWS, and scientists from Science (N63, N73). In November 2017, an arrangement of any three key players listed across each row in Table 5 could reach most (80.95%) of the network.

In June 2018, the key players were a manager (N41) and scientists (N18, N47) from NPWS. They could reach 100% of the network (Table 5), indicating some resiliency and redundancy in the network.

Table 5. Key player (diffuse) in the ALPINE network at each time period.

Time period	Key player query run	Key player (diffuse)	Key player (diffuse)	Key player (diffuse)	Nodes reached (%)
Jul 2017	1	N40 (Regional Ops)	N61 (Science)	N75 (NPWS)	69.05
	2	N40 (Regional Ops)	N62 (Science)	N74 (NPWS)	69.05
	3	N40 (Regional Ops)	N77 (NPWS)	N80 (Regional Ops)	69.05
	4	N40 (Regional Ops)	N78 (NPWS)	N94 (NPWS)	69.05
	5	N40 (Regional Ops)	N94 (NPWS)	N96 (Science)	69.05
	6	N40 (Regional Ops)	N95 (NPWS)	N97 (Regional Ops)	69.05
	7	N41 (NPWS)	N65 (NPWS)	N82 (NPWS)	69.05
	8	N41 (NPWS)	N76 (NPWS)	N95 (NPWS)	69.05
	9	N41 (NPWS)	N77 (NPWS)	N79 (NPWS)	69.05
	10	N41 (NPWS)	N82 (NPWS)	N94 (NPWS)	69.05
Nov 2017	1	N104 (NPWS)	N2 (NPWS)	N56 (Science)	80.95
	2	N2 (NPWS)	N39 (NPWS)	N99 (NPWS)	80.95
	3	N2 (NPWS)	N56 (Science)	N65 (NPWS)	80.95
	4	N2 (NPWS)	N56 (Science)	N98 (NPWS)	80.95
	5	N39 (NPWS)	N73 (Science)	N76 (NPWS)	80.95
	6	N41 (NPWS)	N72 (Science)	N76 (NPWS)	80.95
	7	N41 (NPWS)	N76 (NPWS)	N96 (Science)	80.95
	8	N56 (Science)	N63 (Science)	N76 (NPWS)	80.95
	9	N56 (Science)	N74 (NPWS)	N76 (NPWS)	80.95
Jun 2018	1	N18 (NPWS)	N41 (NPWS)	N47 (NPWS)	100

SEEK networks

The total number of individuals from all time periods in the SEEK network was 124 (Table 6) with 91 internal nodes from four Divisions/ Groups (5 from Heritage, 46 from NPWS, 10 from Regional Operations, 30 from Science) and 33 external nodes from 10 external organisations, companies, associations or community groups (Table 7). The response rate increased between November 2017 (14.5%) and June 2018 (22.6%) (Table 6).

Table 6. Number of individuals in the SEEK network in November 2017 and June 2018.

	Nov 2017	Jun 2018
Attend	18	28
Not Attend	58	96
Not in this Time Period	48	0
TOTAL	**124**	**124**
Response rate	**14.5%**	**22.6%**

Table 7. Number of individuals in each category for the SEEK and SHARE networks in November 2017 and June 2018. One individual may have been nominated several times, but is only counted once for each network.

Category (Attribute)	SEEK Nov 2017	SEEK Jun 2018	SHARE Nov 2017	SHARE Jun 2018
OEH – Heritage (D1)	1	1	1	
OEH – Natl Parks & Wildlife Service (NPWS) (D2)	21	18	22	21
OEH – Regional Operations (D3)	6	7	5	5
OEH – Science (D4)	12	8	14	9
ACT Govt – ACT Env & Heritage (D5)		1	1	1
NSW Govt – NSW Premier & Cabinet, NSW Planning, NSW Primary Industries (D6)	2		2	1
University – ANU, Griffith, La Trobe, Uni Canberra (D7)	3	3	1	1
Traditional Custodian (D8)	2			
Committee – Aust Alps Committee, RAC (D9)		1	1	2
Zoo – Zoos Victoria (D10)		1		1
Resorts – Perisher Blue, Thredbo (D11)	3		2	
Consultant – EcoLogical (D12)	2			
Business – commercial nursery (D13)	1			
Research organisation – Arthur Rylah Institute (D14)		1		1
Company (more than 200 staff) – Snowy Hydro (D15)				1
Research group – NSW Soil Knowledge Network (D16)		1		1
Education – Riverina Env Educ'n Centre (D17)				1
TOTAL OEH individuals nominated	**40**	**34**	**42**	**35**
TOTAL external individuals nominated (% of total individuals nominated)	**13 (24.5%)**	**8 (19.0%)**	**7 (14.3%)**	**10 (22.2%)**

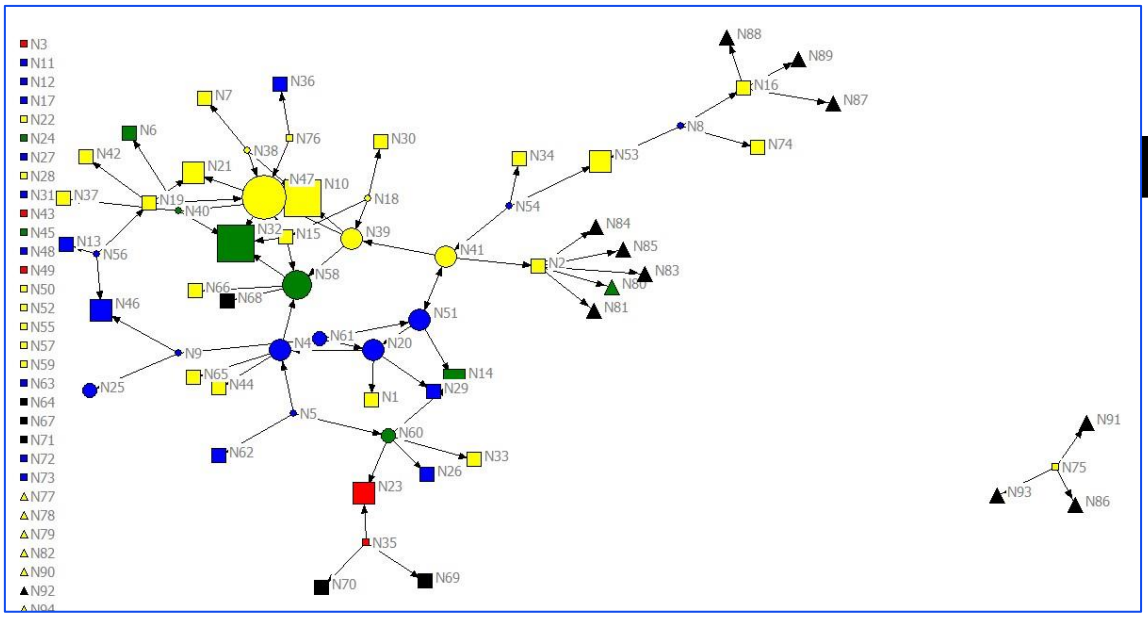

Figure 4. Visualisation of SEEK network for November 2017. Node colour represents OEH Division/ Group or organisation. Red = Heritage (D1)**;** Yellow = NPWS (D2)**;** Green = Regional Operations (D3)**;** Blue = Science (D4); Black = non OEH. Node shape represents attendance: circle = attended; square = did not attend; triangle = not in this time period. Arrow direction indicates whom the node seeks information from.

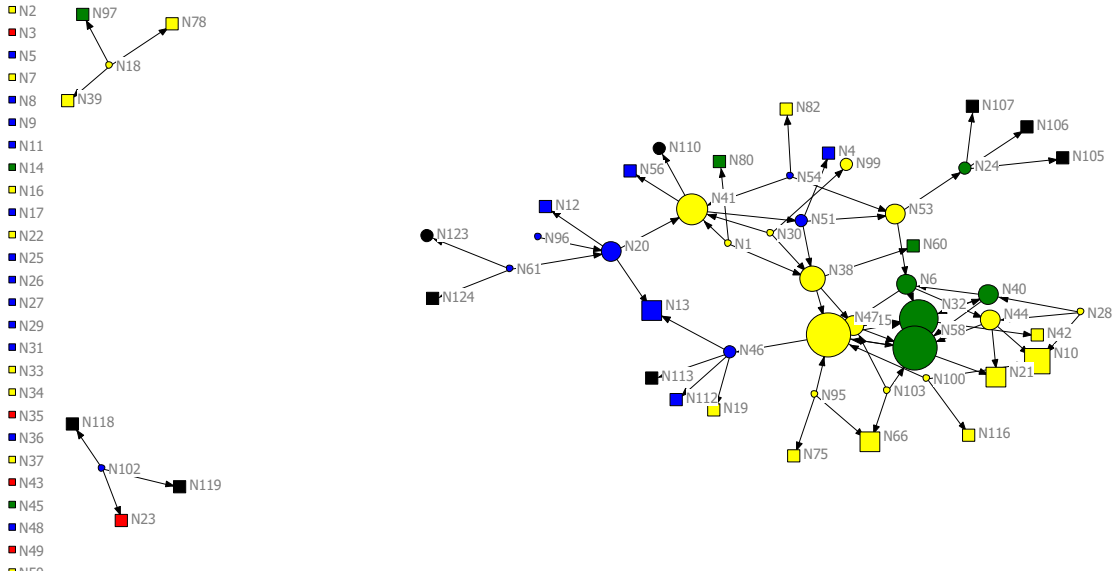

Figure 5. Visualisation of SEEK network for June 2018. Node colour represents OEH Division/ Group or organisation. Red = Heritage (D1); Yellow = NPWS (D2); Green = Regional Operations (D3); Blue = Science (D4); Black = non OEH. Shape of node represents attendance: circle = attended and responded; square = did not attend or respond. The direction of the arrow indicates whom the node seeks information from.

Multiple Cohesion Measures for SEEK network

Between November 2017 and June 2018, the **average degree** did not change for the SEEK networks (Table 8). This indicates people in the network did not SEEK information with more

or different people by June 2018. There were fewer attendees at the meeting in November 2017 than in June 2018 which may have affected the result.

Between November 2017 and June 2018, the **density** of the SEEK network did not change (Table 8), indicating the network did not become more cohesive. However, different participants provided data at each time period, so the lack of difference may reflect varied responses by different individuals.

Between November 2017 and June 2018, the **fragmentation** of the SEEK network decreased (Table 8). This indicates participants sought information from similar people over time.

Between November 2017 and June 2018, the **closure** of the SEEK network increased (Table 8). This suggests more individuals sought information from similar individuals over time. It also suggests, in triads, where originally person A knew both B and C but maybe B and C didn't know each other, that by June 2018, it was more likely that person B and C also knew each other.

Between November 2017 and June 2018, the **diameter** of the SEEK network increased from six to seven steps (Table 8) so it required more steps to access all nodes in the major component of the network by the end of the project. This may indicate the growth of the network.

Table 8. Multiple Cohesion Measure Metrics for SEEK networks over time

Metrics	Nov 2017	Jun 2018
Average degree	0.597	0.589
Density	0.005	0.005
Fragmentation	0.985	0.972
Closure	0.083	0.155
Diameter	6	7

Key players in the SEEK network

The key players in the SEEK network changed over time: a manager from NPWS (N41) was a key player in November 2017 but no longer a key player in June 2018. In November 2017, more key players in the SEEK network were from Science (N5, N8) than NPWS (N41) but, by June 2018, most key players were from NPWS (N1, N53, N30 N47, N53) (Table 9).

Table 9. Key players (diffuse) from the SEEK networks in November 2017 and June 2018; and percent of nodes reached by any combination of the three key players in each row.

Time period	Key player query run	Key player (diffuse)	Key player (diffuse)	Key player (diffuse)	Nodes reached (%)
Nov 2017	1	N41 (NPWS)	N5 (Science)	N8 (Science)	22.31
Jun 2018	1	N1 (NPWS)	N4 (Science)	N53 (NPWS)	19.84
	2	N30 (NPWS)	N47 (NPWS)	N53 (NPWS)	19.84

SHARE networks

The total number of individuals in the SHARE network from both time periods (November 2017, June 2018) was 124 (Table 10) with 91 internal nodes from four OEH Groups/ Divisions

(5 from Heritage, 46 from NPWS, 10 from Regional Operations, 30 from Science) and 33 external nodes from 13 categories. The response rate for the SHARE network in November 2017 was 14.5% and 22.6% in June 2018 (Table 10). The attendance of individuals in the SHARE network is provided in Table 10.

The SHARE networks for November 2017 and June 2018 were visualised in Figure 6 and Figure 7 respectively.

Table 10. Number of individuals in the SHARE network at each time period

	Nov 2017	Jun 2018
Attend - response	18	28
Did not attend – no response	58	96
Not in this time period – no response	48	0
TOTAL	**124**	**124**
Response rate	**14.5%**	**22.6%**

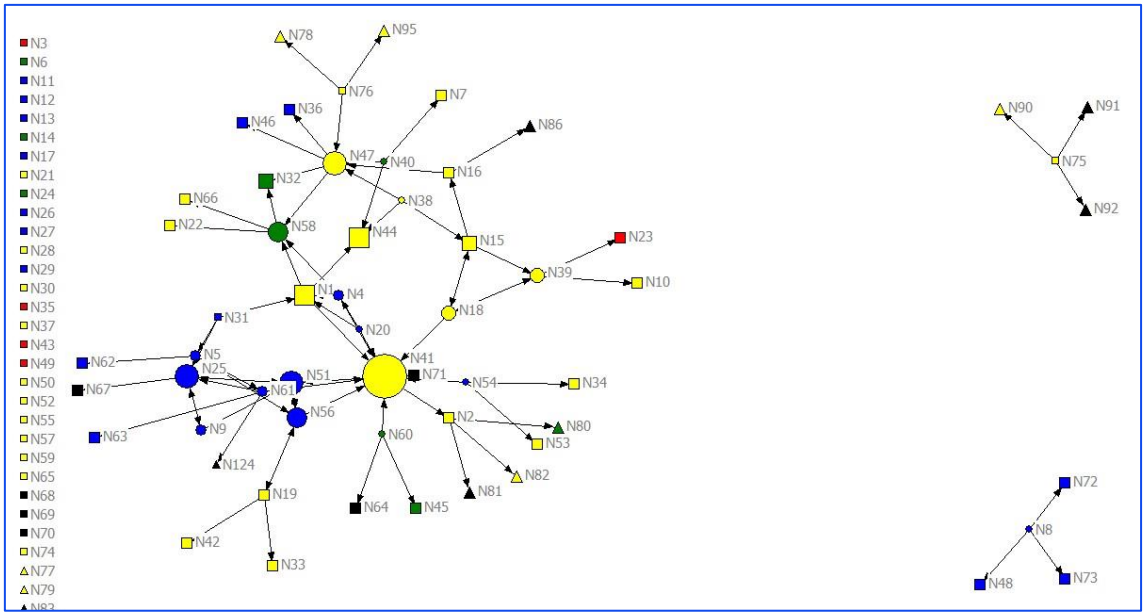

Figure 6. Visualisation of SHARE network for November 2017. Isolates are listed on the left of the visualisation. Node colour represents OEH Division/ Group or organisation. Red = Heritage (D1)**;** Yellow = NPWS (D2)**;** Green = Regional Operations (D3)**;** Blue = Science (D4); Black = non OEH. Node shape represents attendance: circle = attended; square = did not attend; triangle = not in this time period. Arrow direction indicates whom the node shares information with.

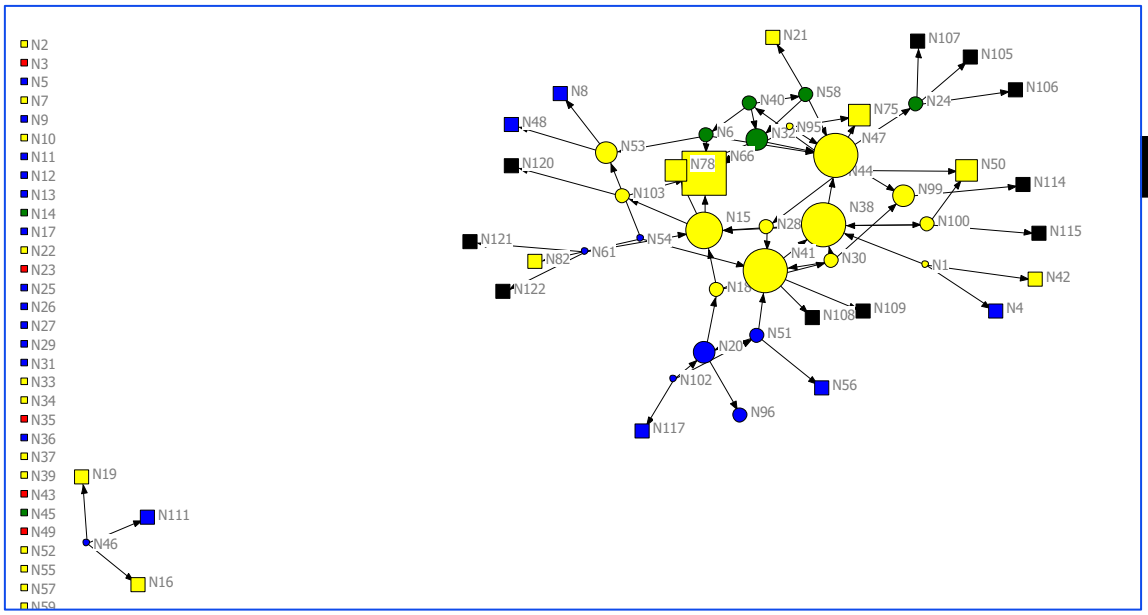

Figure 7. Visualisation of SHARE network for June 2018. Isolates are listed on the left. Node colour represents OEH Division/ Group or organisation. Red = OEH Heritage (D1)**;** Yellow = OEH NPWS (D2)**;** Green = OEH Regional Operations (D3)**;** Blue = OEH Science (D4); Black = non OEH. Node shape represents attendance where circles = attended; square = did not attend. Arrow direction indicates whom the node shares information with.

Multiple Cohesion Measures for SHARE network

Between November 2017 and June 2018, the **average degree** decreased for the SHARE network (Table 11). This indicates that, before the final meeting, individuals reported they shared with fewer people than before the previous meeting. The response rate in November 2017 was lower than in June 2018 which may have affected the result.

The **density** of the SHARE networks did not change between November 2017 and June 2018 (Table 11) so the network did not become more cohesive. However, different participants provided data at each time period, so the lack of difference may reflect varied responses by different individuals.

Between November 2017 and June 2018, the **fragmentation** of the SHARE network increased (Table 11). This indicates participants shared information with more people over time.

Between November 2017 and June 2018, the **closure** of the SHARE network remained the same (Table 11) indicating individuals did not share information with more or different individuals over time.

Between November 2017 and June 2018, the **closure** of the SHARE network did not change (Table 11) which indicates participants sought information from a similar number and distribution of individuals throughout the project.

Between November 2017 and June 2018, the **diameter** of the SHARE network decreased from eight to seven steps (Table 11).

Table 11. Multiple Cohesion Measure Metrics for SHARE network over time

Metrics	Nov 2017	Jun 2018
Average degree	1.129	1.113
Density	0.009	0.009
Fragmentation	0.844	0.857
Closure	0.127	0.128
Diameter	8	7

Key players in the SHARE network

The key players in the SHARE network changed between November 2017 and June 2018 (Table 12). By June 2018, the key player from NPWS (N41) in November 2017 was replaced by key players from Science (N20, N51, N102) and another manager from NPWS (N38). Another individual from NPWS (N47) remained a key player in the SHARE network in November 2017 and June 2018.

Table 12. Key players (diffuse) from the SHARE network over time; and percent of nodes reached

Time period	Keyplayer query run	Key player (diffuse)	Key player (diffuse)	Key player (diffuse)	Nodes reached (%)
Nov 2017	1	N41 (NPWS)	N47 (NPWS)	N72 (Science)	36.36
	2	N41 (NPWS)	N47 (NPWS)	N73 (Science)	36.36
	3	N41 (NPWS)	N47 (NPWS)	N75 (NPWS)	36.36
	4	N41 (NPWS)	N47 (NPWS)	N8 (Science)	36.36
	5	N41 (NPWS)	N47 (NPWS)	N90 (NPWS)	36.36
Jun 2018	1	N102 (Science)	N38 (NPWS)	N47 (NPWS)	31.41
	2	N20 (Science)	N38 (NPWS)	N47 (NPWS)	31.41
	3	N38 (NPWS)	N47 (NPWS)	N51 (Science)	31.41

Survey results

A total of 22 people (73%) provided feedback in an online survey about the meeting on 25 July 2017. Respondents were from Heritage (1), NPWS (6), Regional Operations (1) and Science (10). Four respondents did not nominate a Division/ Group. The opportunity to meet colleagues from across OEH was considered the best part of the meeting. Respondents said they met at least one new person at the meeting. Half the staff who attended (50%, n=11) met 1-5 new people at the meeting, eight staff (36%) met 6-10 new people, and three staff (14%) met more than 10 new people. Participants said they would have liked more time to network during the meeting.

A total of 10 people gave feedback (of the 18 who attended) on the workshop in November 2017. Respondents were from NPWS (3), Regional Operations (2) and Science (5). They considered the best part of the workshop was meeting colleagues and participating in the discussion. Everyone who responded said they met new people, with most respondents (80%, n=8) saying they met 1-5 new people, with the rest (20%, n=2) meeting 6-10 new people.

Discussion and Conclusions

ALPINE NETWORK

Over the 12 months of the analysis, the **ALPINE** network remained dynamic. Many individuals joined the network during the project period while others became inactive at some times. Individuals who remained in the network for the duration were probably those with expertise, experience, responsibilities or interest in the alpine region.

Response rates declined over the project period (Table 1) because the network grew and not all individuals in the network at the time provided data and/ or were nominated (i.e. inactive nodes). The low response rates may affect results.

Betweeness explores the brokerage role of individuals in the network. In July 2017, two senior managers from Science and NPWS had the highest **betweenness scores** in the network (Table 3), probably because they were known by many individuals prior to formation of the network. One of these managers (from NPWS) maintained a high betweenness score throughout the project, reflecting their diverse links within the network and their role in brokering information within the network. However, in November 2017, another NPWS manager achieved the highest betweenness score for the project period. This individual did not attend any meetings, and their high score likely reflects bias – the individual provided data sheets to individuals who were not on the supplied list and they responded. In June 2018, this individual did not complete data sheets nor pass data sheets to others, so did not maintain a high betweenness score at this time. By June 2018, the senior manager from NPWS (N41) achieved a high betweenness scores indicating they returned to function as a broker between Groups and Divisions.

Over the three meetings, the **average degree** of the ALPINE network increased (Table 4) indicating each individual was connected to more people in the network by the end of the project. The ALPINE network also became more **dense** (Table 4), indicating people built connections with more individuals in the network over time. It also became **less fragmented** (Table 4), indicating better connection between individuals over time. The ALPINE network had similar **closure** throughout the three meetings (Table 4), indicating it remained closed throughout the project period. This may reflect that the network is within an organisation, where some relationships will already have formed between individuals before the project began.

Key players are individuals with the greatest reach and influence in the network (Cunningham *et al*., 2017) who perform different roles depending on the type of network**. The reach of the key players** in the ALPINE network increased from 69.05% in July 2017 to 100% in June 2018 (Table 5), indicating there was resiliency or redundancy in the network by the end of the time period. The composition of key players also changed over time, with the role of individuals from Regional Operations being replaced by key players from NPWS by June 2018. One again, a senior manager from NPWS maintained a crucial role throughout the project period.

SEEK AND SHARE NETWORKS

The ALPINE network has little connection through the SEEK or SHARE networks to external sources of information (Table 7). By June 2018, information was sought from a higher percentage of external individuals, but shared with a lower percentage of external individuals (Table 7).

In November 2017, individuals in the network mostly SEEK information about the alpine region from OEH scientists in NPWS (N10, N47) and Regional Operations (N32, N58) (Figure 4) rather than consultants, or individuals in universities or other institutions. People also SEEK information from managers from NPWS (N41) and Science (N51) who link Divisions and Groups. By June 2018 (Figure 5), more individuals sought information from scientists in Regional Operations (N32, N58) and NPWS (N47). However, an NPWS manager (N41) remained a source of alpine information.

The **average degree, density** and **fragmentation of the SEEK network** remained similar throughout the project period. However, the **diameter** of the SEEK network increased over time indicating the network grew over time. The **closure** of the SEEK network increased over time indicating individuals in the network sought information from similar individuals over time.

The **diameter of the SHARE network** decreased between November 2017 and June 2018 which may be due to the emergence of new key players in the network (N38, N47) in June 2018 (Table 8). However the **average degree, density, fragmentation and closure** of the SHARE network did not change over time, suggesting individuals did not share information with more or different individuals over time.

In November 2017, individuals in the network mostly SHARE information about the alpine region with OEH managers (N38, N41). However, they also SHARE information with an NPWS ranger (N66) and a NPWS Discovery Coordinator (N99). By June 2018, more NPWS staff were sharing information with NPWS managers (N15, N38, N41, N44). An NPWS ranger (N66) was also someone others shared information with.

Some key players from NPWS (N41, N47) and Science (N8), were common to the SEEK and SHARE networks which may indicate that alpine expertise in OEH is concentrated in a few individuals. However, it may also indicate that individuals in the network approach trusted sources to seek and share information. Individuals who were nominated in both the SEEK and SHARE networks have experience in the alpine region as a scientist (N47) or manager (N41). Interestingly, people SEEK some information from Science Division, but rarely SHARE it with Science Division, indicating Science Division needs to improve connection to the ALPINE network.

The reach of the **key players** remained similar during the project period in both the SEEK (22.3% in Nov 2017 to 19.8% in June 2018) (Table 9) and SHARE network (36.4% in Nov 2017 to 31.4% in June 2018) (Table 12). However, key players in the SHARE network had more reach than those in the SEEK network.

In summary, the meetings built more and stronger connection between individuals in the ALPINE network. Some individuals are key players and critical to maintain connection, and share knowledge between Groups and Divisions. However, the network is very insular which could restrict the flow of novel information into the network.

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