Advancing Collaboration at Boise State

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Advancing Idaho: The Grand Challenges

Wicked problems are marked by their interconnectedness, and the repercussions ripple through various social systems.

Addressing wicked problems requires new ways of thinking and collaboration across academic disciplines, governing agencies, and community members.

Idaho's Grand Challenges

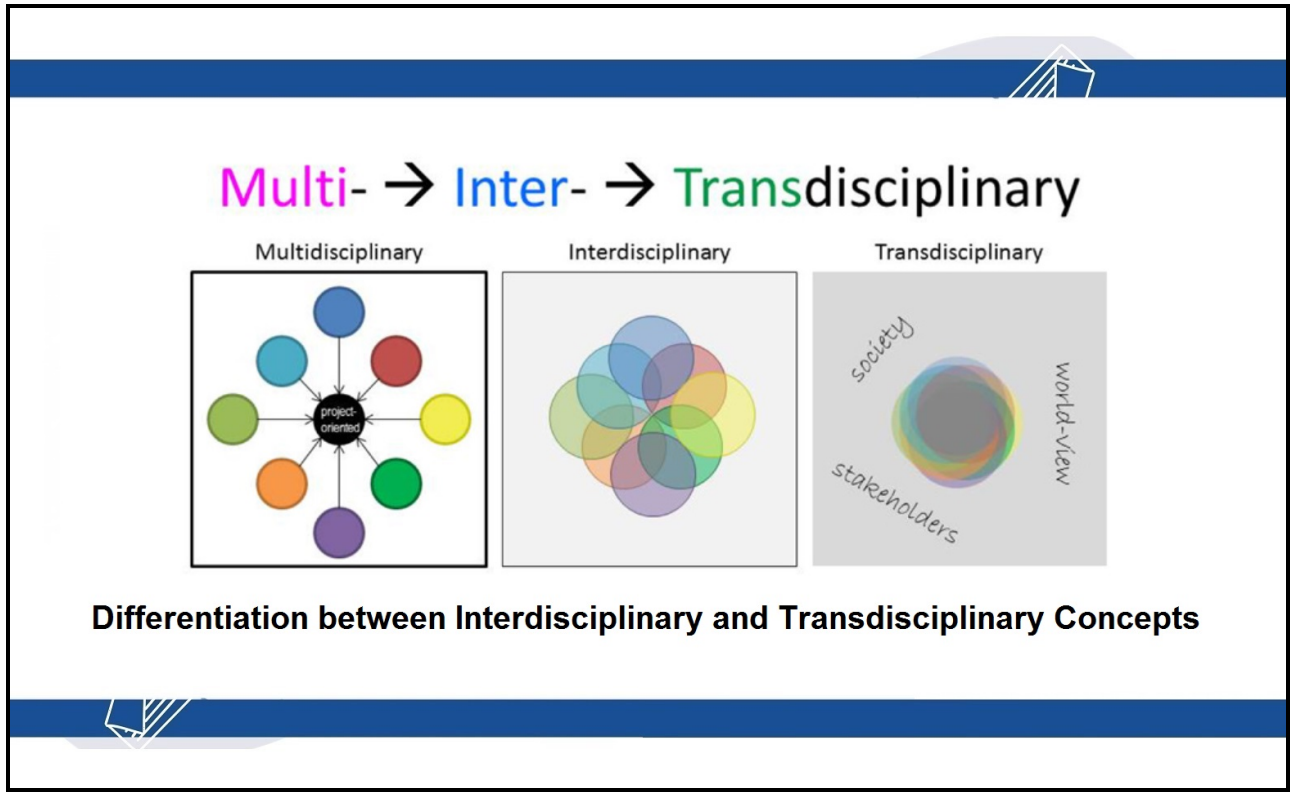
Resource Nexus for Sustainability

Explores complex interactions between natural and built environments like urban development and sustainability of energy and water resources.

Healthy Idaho

Seeks to improve physical and social conditions to foster healthy and thriving communities throughout Idaho.

Two key Grand Challenges at Boise State bring together researchers, students, and partners to tackle complex societal issues.



The Power of Interdisciplinary Collaboration

A comprehensive understanding of issues.

Higher probability of generating radical innovations.

Multiple perspectives for verifying results.

Encouraged and prioritized by funding agencies.

Emphasizes authentic "convergent" collaboration between STEM and social sciences.

Thesis

Insights into enhancing interdisciplinary collaboration can be gained through a detailed analysis of the socio-relational structures and institutional context.

Research Questions

In what ways do researchers conceptualize collaboration?

What are the diverse forms of collaboration?

What are the dynamics of grant proposal collaborations?

What is the relationship history of Grand Challenges team members?

Research Branches Studying Collaboration

VAMPIRE

Analyzes faculty interviews to explore academic culture and collaboration themes.

CUPID

Uses social network analysis on grant data to study grant networks.

LOVE

Surveys interdisciplinary teams about their characteristics and collaborations.

Three different methods used to study collaboration.

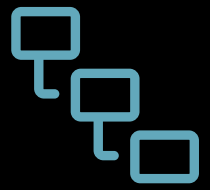
VAMPIRE

Vicken And Many Persons Interview Research Enterprise

Thematic Analysis

Academic culture

Foster a culture of achievement, innovation, and interdisciplinary collaboration.



Institutional structures

Creating space, workload policies, and funding that can support and inhibit collaborative work.

Interpersonal dynamics

Build relationships of trust, respect, and understanding between collaborators.

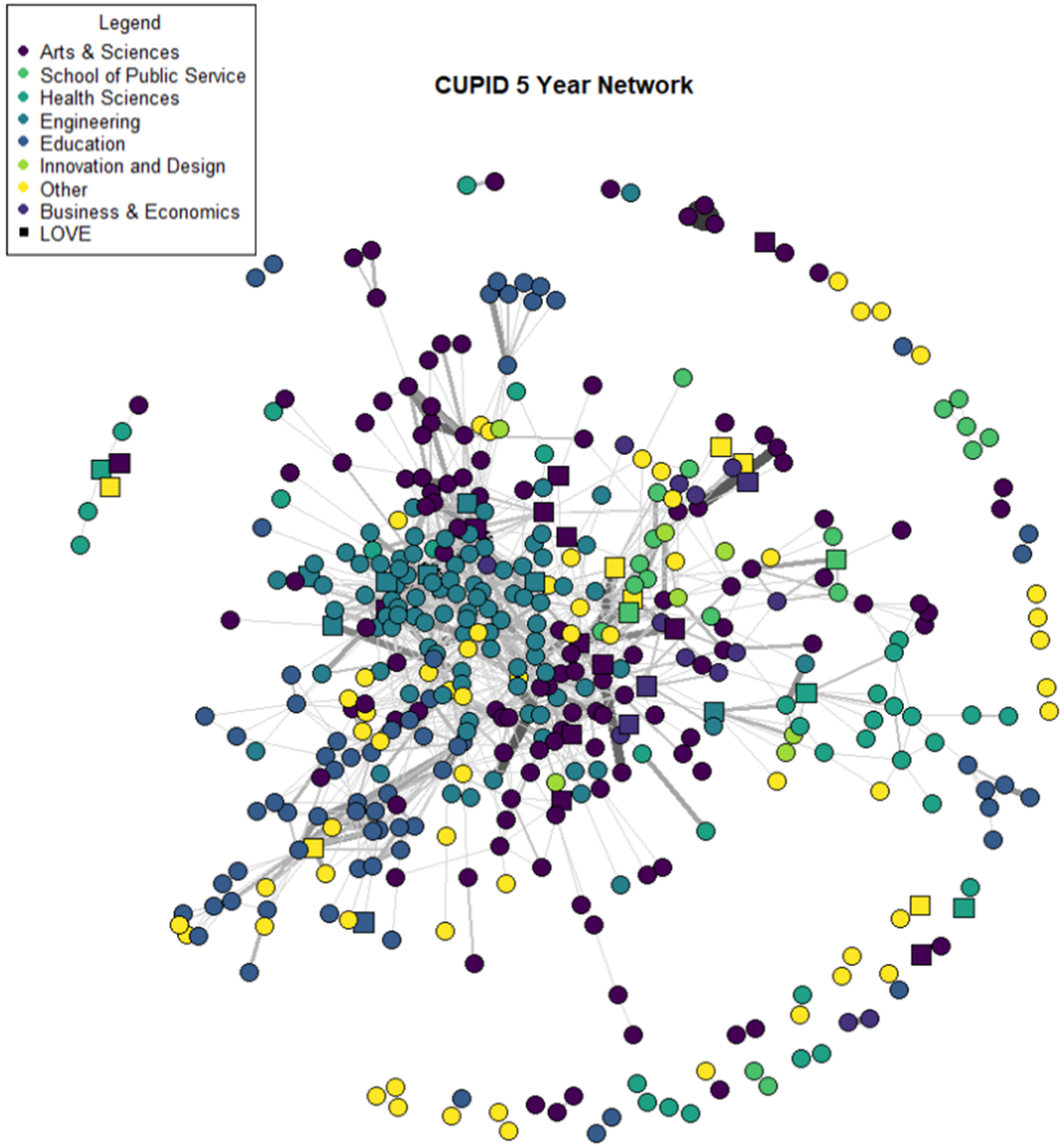
By improving these key areas, we can enhance interdisciplinary collaboration at our university.

Social Network Analysis (SNA)

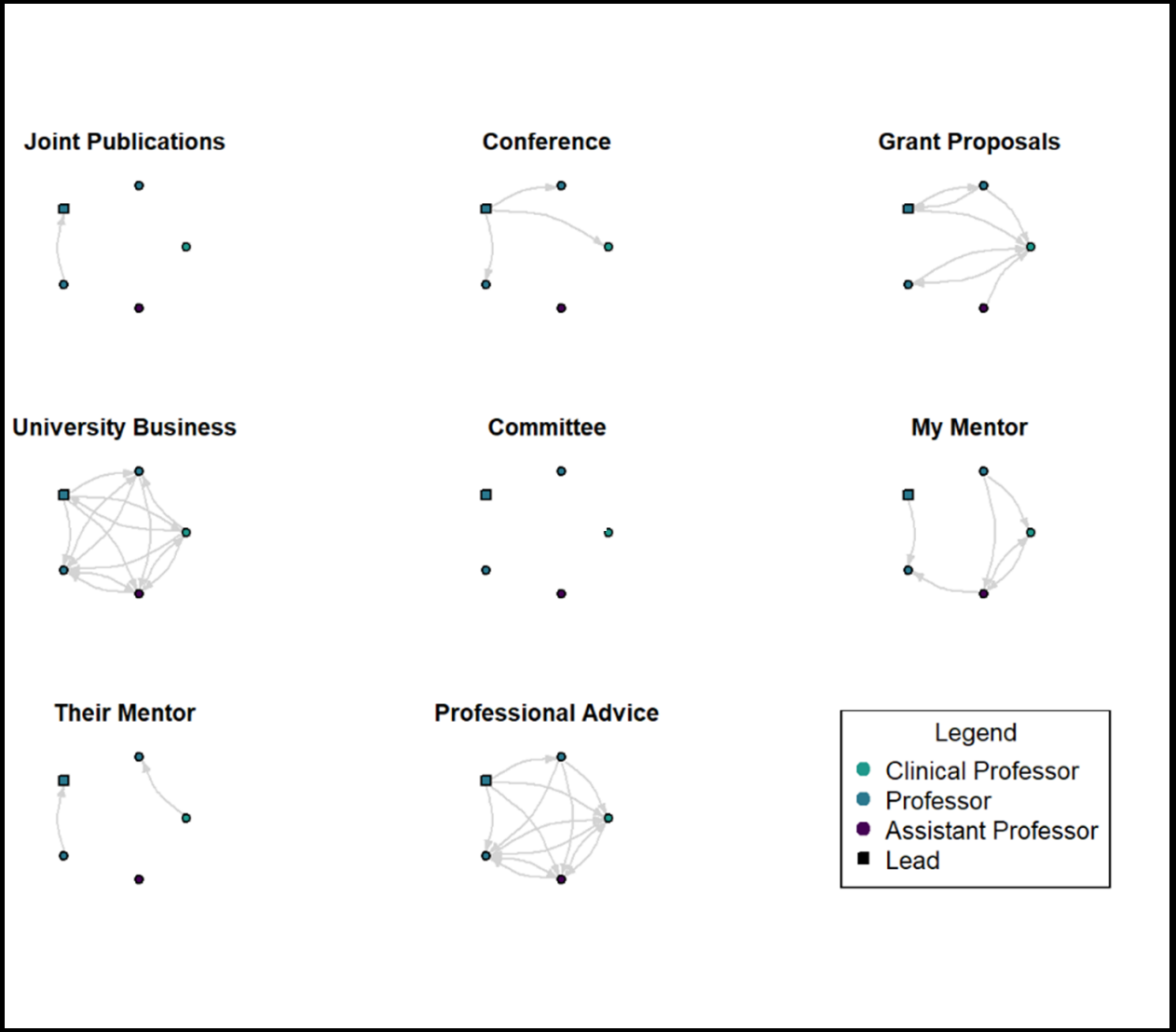
Actors and Ties: Networks comprise actors (researchers) and relationships (ties) among them.

Edges: Specific contexts form relationships, connecting researchers and quantifiable through SNA.

Example: Sharing a grant proposal creates an edge between researchers.



Degree and Betweenness Centrality



Degree Centrality

The number of ties a node has.

A high degree takes the shape of a star.

Betweenness Centrality

Quantifies the frequency with which a node appears along the shortest paths between other pairs of nodes in the network.

CUPID

Collective Understanding of PI Data

Research Questions

- How do relationships and network structures contribute to the development of scientific work?
- How have the dynamics of grant networks at Boise State evolved?

Hypotheses

- Researchers tend to collaborate with peers who have gained influence through numerous prior joint projects.
- Faculty members tend to collaborate with peers from their college.

Year	Network Size	Proposal Count	Collaborative Proposals	Edges
2016	207	457	166	335
2017	213	502	159	355
2018	214	537	174	406
2019	213	480	155	339
2020	169	408	112	360
5yr	446	2384	766	1284

Table of primary descriptors of historical grant proposal networks from 2016 to 2020

Measuring Cumulative Advantage

Hypothesis 1: Researchers tend to collaborate with peers who have gained influence through numerous prior joint projects.

Degree Centrality

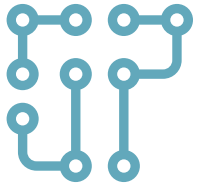
Few scientists or scholars receive disproportionate offers to collaborate.

Gini Coefficient

Whether co-proposals are evenly spread across the faculty.

Degree Popularity

Alternating signs for star counts in simulated networks, adjusting the weight given to nodes based on their degree.



Differential homophily

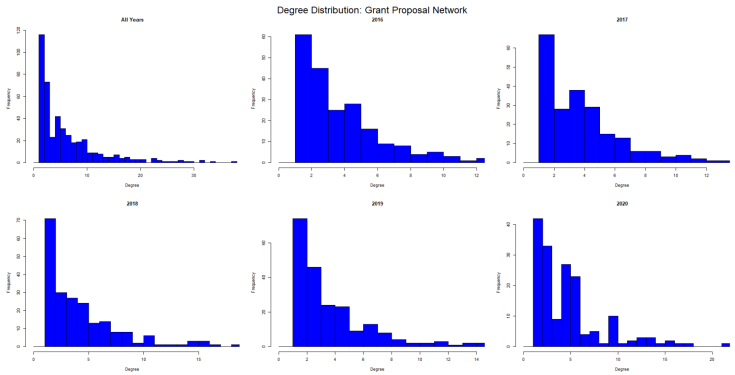
The propensity of researchers to engage in grant proposal collaborations with peers who exhibit similar levels of co-proposal activity.

Measures like the Gini coefficient, degree centrality, and degree popularity help quantify cumulative advantage where dispersion across the network suggests equitable distribution.

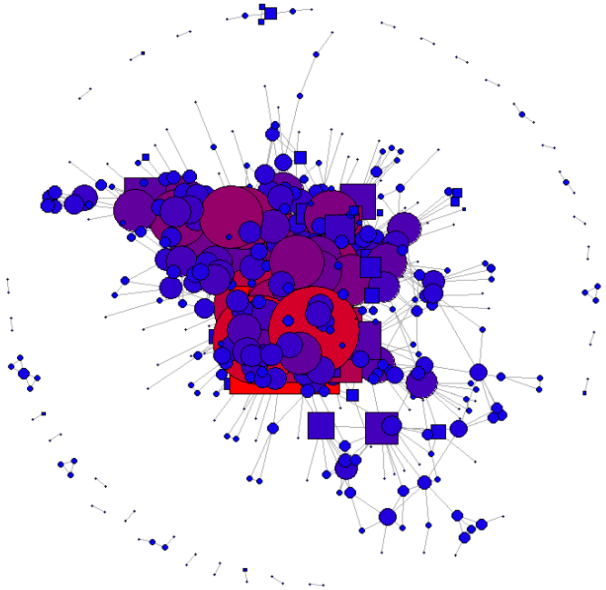
Cumulative Advantage Results

Degree Centrality

A smaller group of faculty members propose on grants with a larger share collaborators.



	All5Years	2016	2017	2018	2019	2020
Gini	0.6086637	0.7175758	0.7096886	0.7358678	0.7262788	0.787226



Degree Distribution

Histograms with the five-year network first, then each year in order. Right-skewed plots indicate a pattern of "stars."

Gini Coefficient

The table of Gini coefficients calculated for the degree distribution shows a high level of inequality in collaborative co-proposal involvement.

Degree Centrality of 5-Year Network

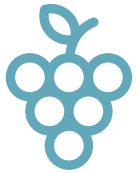
Network Plot of 5-year historical grant proposal network. Node size and color indicate the degree, with larger, redder nodes indicating more frequent collaboration. Square nodes represent GCs team members.

Measuring Interdisciplinary Distance

Hypothesis 2: Faculty members tend to collaborate with peers from their college.

Betweenness Centrality

Broker facilitates or restricts the integration of peripheral members into the core collaborative framework.



Network Visualizations

Visual inspection for researchers from various colleges clustering.

Uniform Homophily

The tendency to form ties with others who have similar attributes.

Transitivity

Friends of my friends are also my friends.

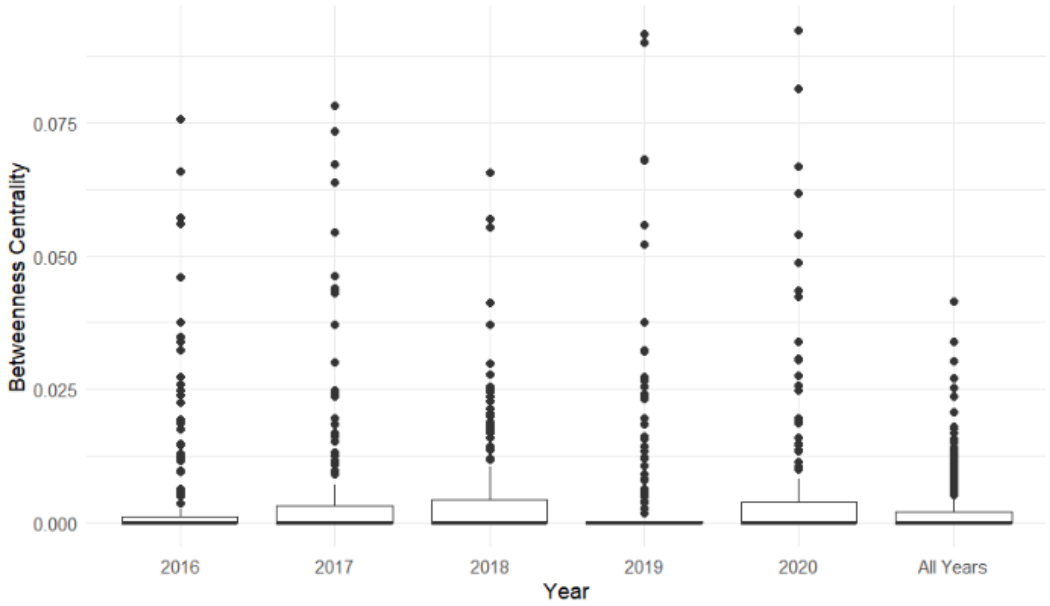
Reflecting the network's tendency for triadic closure.

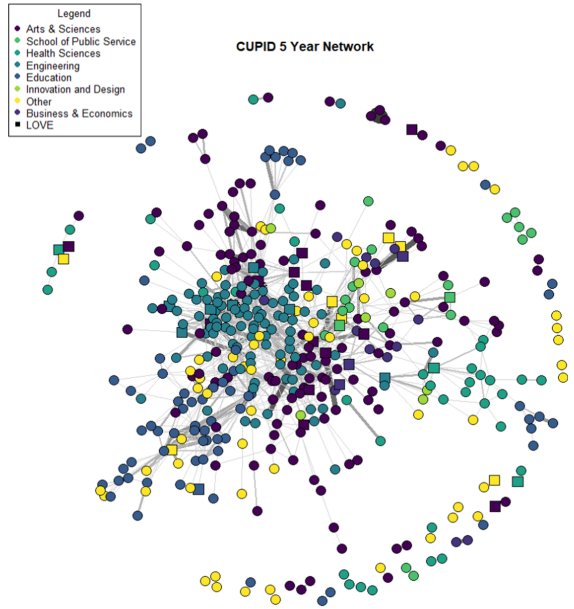
Same college collaborations are either collaborating within a discipline or within a short distance of their discipline. Different college collaborations are "super-distance."

Interdisciplinary Distance Results

Betweenness Centrality

Bridges across disciplinary gaps may enhance access to resources and collaborative opportunities.





Betweenness Distribution

Box plots of normalized betweenness with the five-year network first, then each year in order. The consistent spread of outliers over the years may reflect established broker roles within the research community that persist over time.

5-Year Network

Network Plot of 5-year historical grant proposal network. Utilizing the Fruchterman-Reingold algorithm, the layout accentuates the clustering of nodes based on the number of shared grant proposals. Colors by college.

Exponential random graph models (ERGMs)

A type of statistical model similar to logistic regression.

Tie (edge formation) is the outcome variable.

Attributes and structure are independent variable.

Models network structures while controlling for individual attributes.

A tie-level interpretation.

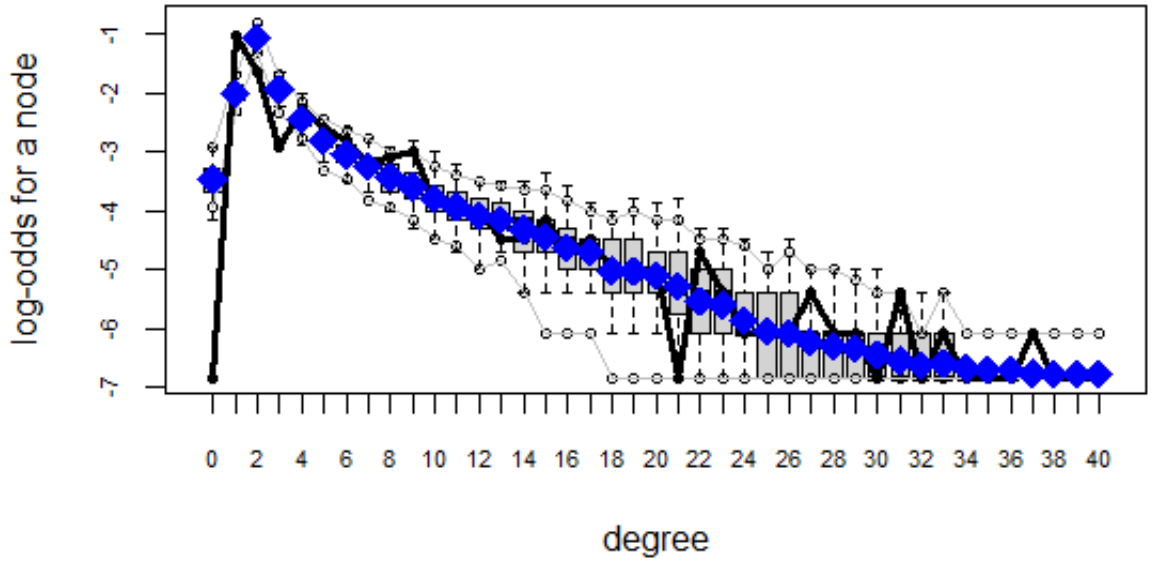
MCMC generates sample networks using observed data node and edge counts, allowing for estimating parameters that best represent the underlying social processes shaping the network.

```
Call:
ergm(formula = network_Full5yr_All ~ edges + nodemix("prop_quartile") +
    nodefactor("College") + nodematch("College", diff = TRUE) +
    gwdegree(0.35, T) + gwesp(0.35, T), eval.loglik = T, control = control.ergm(MCMC.samplesize = 10000,
    MCMC.burnin = 1e+05, MCMC.interval = 1000, seed = 567), verbose = T)

Monte Carlo Maximum Likelihood Results:

                                          Estimate Std. Error MCMC % z value Pr(>|z|)
edges                                   -10.48366    0.35038      0 -29.921  < 1e-04 ***
mix.prop_quartile.1.2                     0.52340    0.25707      0   2.036 0.041745 *
mix.prop_quartile.2.2                     1.31860    0.38993      0   3.382 0.000721 ***
mix.prop_quartile.1.3                     0.72794    0.23769      0   3.062 0.002195 **
mix.prop_quartile.2.3                     1.85877    0.30258      0   6.143  < 1e-04 ***
mix.prop_quartile.3.3                     2.04987    0.30113      0   6.807  < 1e-04 ***
mix.prop_quartile.1.4                     0.98916    0.22114      0   4.473  < 1e-04 ***
mix.prop_quartile.2.4                     1.86755    0.29141      0   6.409  < 1e-04 ***
mix.prop_quartile.3.4                     2.29764    0.28886      0   7.954  < 1e-04 ***
mix.prop_quartile.4.4                     2.54906    0.28873      0   8.829  < 1e-04 ***
nodefactor.College.Business_&_Economics   0.10104    0.12144      0   0.832 0.405432
nodefactor.College.Education             -0.07747    0.07522      0  -1.030 0.303026
nodefactor.College.Engineering           -0.02210    0.07671      0  -0.288 0.773260
nodefactor.College.Health_Sciences       -0.18579    0.13340      0  -1.393 0.163718
nodefactor.College.Innovation_and_Design  0.34428    0.11452      0   3.006 0.002645 **
nodefactor.College.Other                  0.33685    0.07442      0   4.526  < 1e-04 ***
nodefactor.College.School_of_Public_Service 0.05614  0.11376      0   0.494 0.621637
nodematch.College.Arts_&_Sciences         0.87990    0.10537      0   8.350  < 1e-04 ***
nodematch.College.Business_&_Economics    2.08352    0.23722      0   8.783  < 1e-04 ***
nodematch.College.Education               1.57093    0.12385      0  12.684  < 1e-04 ***
nodematch.College.Engineering             0.96073    0.10108      0   9.505  < 1e-04 ***
nodematch.College.Health_Sciences         2.03462    0.22102      0   9.206  < 1e-04 ***
nodematch.College.Innovation_and_Design   1.84795    0.57158      0   3.233 0.001225 **
nodematch.College.Other                   0.68457    0.17487      0   3.915  < 1e-04 ***
nodematch.College.School_of_Public_Service 1.92168   0.21775      0   8.825  < 1e-04 ***
gwdeg.fixed.0.35                          3.86187    0.31135      0  12.403  < 1e-04 ***
gwesp.fixed.0.35                          3.28750    0.10425      0  31.535  < 1e-04 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

     Null Deviance: 137569  on 99235  degrees of freedom
 Residual Deviance:   8728  on 99208  degrees of freedom

AIC: 8782  BIC: 9038  (Smaller is better. MC Std. Err. = 0.7134)
```

Cumulative Advantage Results

ERGM Terms

Scientific Stars are spread out.



High activity researchers tend to collaborate more.

Variable	Estimate	StdError	zvalue	pvalue
edges	-10.48366	0.35038	-29.921	< 1e-04
mix prop quartile 1.2	0.52340	0.25707	2.036	0.041745
mix prop quartile 2.2	1.31860	0.38993	3.382	0.000721
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mix prop quartile 1.4	0.98916	0.22114	4.473	< 1e-04
mix prop quartile 2.4	1.86755	0.29141	6.409	< 1e-04
mix prop quartile 3.4	2.29764	0.28886	7.954	< 1e-04
mix prop quartile 4.4	2.54906	0.28873	8.829	< 1e-04

Degree Popularity (GWDegree)

The significant positive estimate (3.86187, p < 1e-04) signifies edge dispersion across the network, suggesting a more equitable distribution of ties, where connections are spread out rather than centralized around specific scientific stars.

Differential Homophily

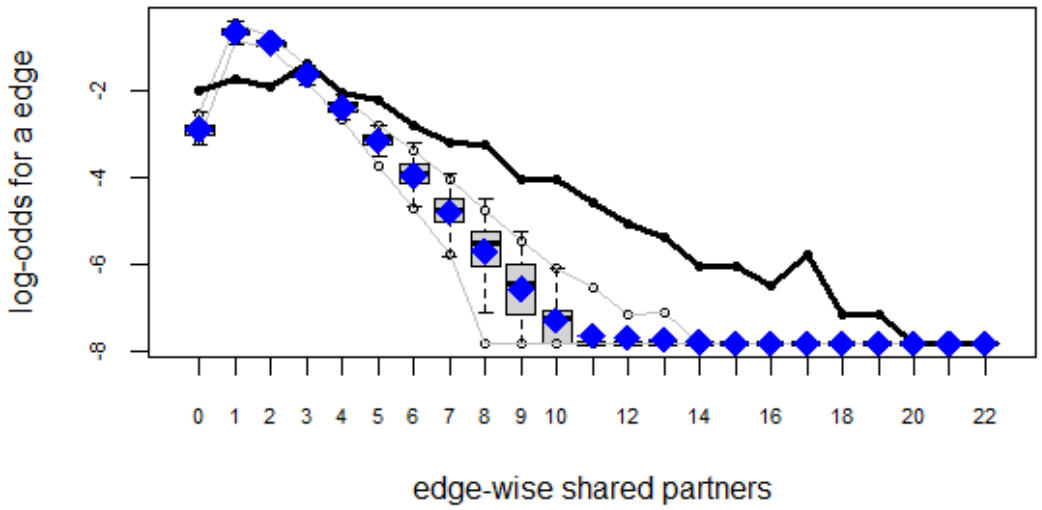
Table of ERGM results shows researchers who are highly active in submitting proposals are not only more likely to work with each other, but this tendency strengthens as the level of activity and recognition increases.

Interdisciplinary Distance Results

ERGM Terms

The likelihood of tie formation between two individuals is higher than expected by chance.

Faculty members are significantly more likely to collaborate on grant proposals within their college.



Variable	Estimate	StdError	zvalue	pvalue
edges	-10.48366	0.35038	-29.921	< 1e-04
nodematch College Arts & Sciences	0.87990	0.10537	8.350	< 1e-04
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nodematch College Other	0.68457	0.17487	3.915	< 1e-04
nodematch College School of Public Service	1.92168	0.21775	8.825	< 1e-04

Transitivity (GW Edgewise Shared Partners)

The presence of shared collaborators between two faculty members significantly increases the likelihood of them co-proposing a grant, aligning with the concept that mutual connections can foster new collaborations due to perceived social value or affinity.

Uniform Homophily Table

The positive coefficients across all college categories indicate a clear trend of Homophily—faculty members are significantly more likely to collaborate on grant proposals with colleagues from their own college than with those from different colleges.

CUPID

Collective Understanding of PI Data

Future Research

- Investigate ERGMs for each year.
- Include community detection algorithms longitudinal method.
  (Sciabolazza et al., 2017)
- 2021-2023 data is available.
- Awarded Grants Networks.

Conclusions

- Researchers tend to collaborate with peers who have gained influence through numerous prior joint projects.
- Faculty members tend to collaborate with peers from their college.

LOVE

Small Teams Networks

The Grand Challenges (GCs) initiative invests in interdisciplinary research teaming.

Resilient Teams

Roster growth

Prevent turnover

Interdisciplinary

Merge disciplines

Productive Teams

Produce creative work

Secure funding

Survey Teams with Roster

Replicated Love et al., 2021 Mid-point survey

CRCA can adapt network treatments aimed at accelerating transdisciplinary work and expanding new opportunities across the university.

LOVE

Small Team Networks: Team Resilience

Research Questions

- What is the nature of collaborative relationships between team members when the team is formed?
- What are the network approaches to evaluate team resilience?

Hypotheses

- Full professors serve as the primary nodes of guidance and expertise.
- Teams with diverse research experience are positioned to foster mentorship.
- Out-degree and betweenness centrality quantitatively assesses the ability to integrate disciplines.
- Degree in Personal network predicts the team's ability to garner resources and support within the team.

Measuring Team Resilience

Mentoring, interdisciplinarity, and learning foster team resilience.

Facility Positions

Faculty of higher rank are more likely to have a history of high research productivity and are positioned to be mentors.

Assesses team members' capacity for facilitating mentor-mentee relationships.

Faculty Department

Interdisciplinarity is a core requirement for the GCs teams.

Mentoring and Advice

What are the previous mentoring and advice relationships among team members?

Teams offering mentoring broaden opportunities.

Encourage student and junior faculty researchers to become core contributors.

Promotes a fair, equitable, and accessible environment.

Convergance

Learning about team members' disciplines aids in disciplinary integration.

Interpersonal Relationships

Effective collaboration often lies in informal, interpersonal connections.

Strategic recruitment is essential to counteract the tendency for systemic biases.

Case Study Teams

Grand Challenges (GCs)

Case Study Team J is presented in this presentation.

GC Leadership Teams

2 Teams, one for each GC.

Create calls for proposals.

Evaluate and rank submissions.

Allocation of awards.

Seek future funding.

GC Award Teams

Larger funding.

5 Teams.

Conduct a pilot study.

Seek additional extramural funding.

Interdisciplinary Research Advancement Teams

Network interventions through Interdisciplinary Research Accelerator.

Smaller funding.

5 Teams.

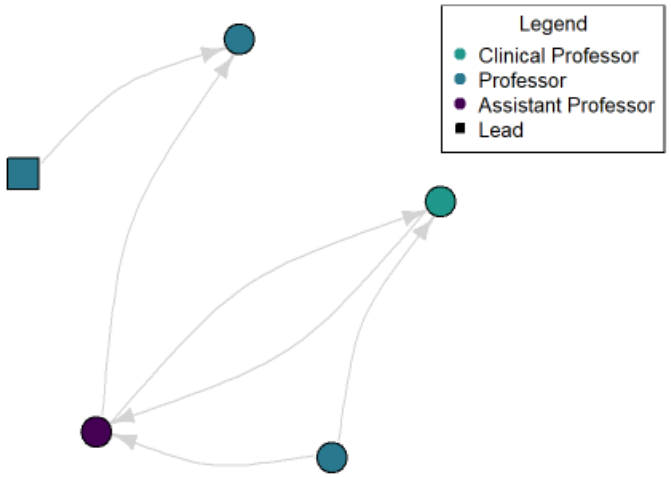
Aims to become a research center.

Team Resilience Results

My Mentor, Their Mentor, and Advice Networks

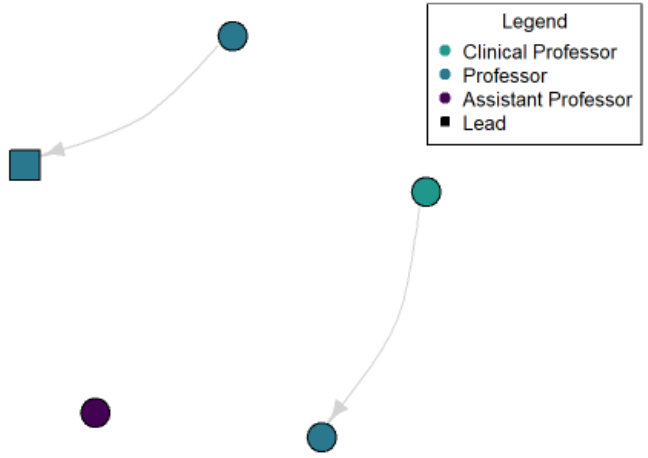
Concordance: the level of agreement or consistency in the reporting of relationships between individuals.

Low concordance suggests mentoring role disparities.



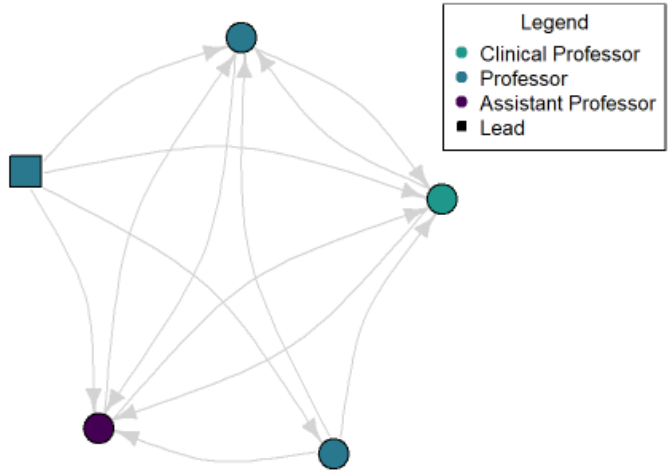
My Mentor Network Visualized

In-degree of the My Mentor and Professional Advice networks indicates the individual's status as a valued mentor within the network.



Their Mentor Network Visualized

Scantiness suggests a reluctance to identify as a mentor.



Professional Advice Network

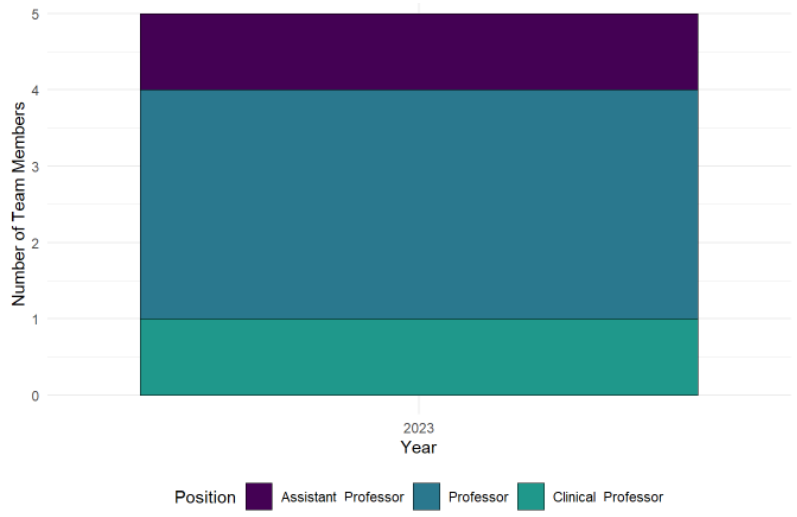
Professors are central to the flow of advice, as reflected by their higher total degree and In-degree measures.

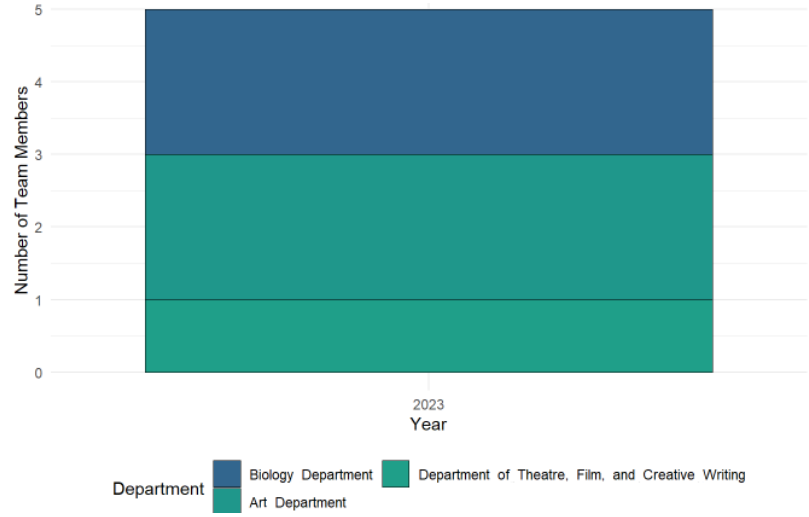
Team Resilience Results

Position and Department Diversity

Teams with position diversity positioned to foster mentorship.

Teams with department diversity are interdisciplinary.





Position Diversity

Team J may benefit from network interventions where network analysis identifies specific individuals whose collaboration with the team will improve Boise State's research networks' structural properties (Vacca et al., 2015).

Department Diversity

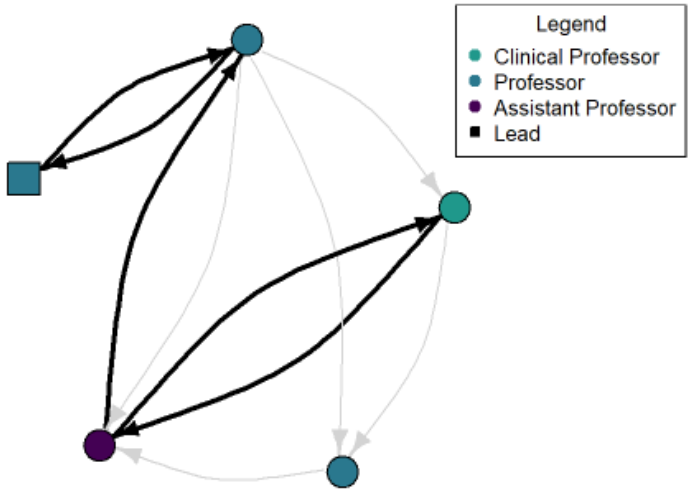
Measured within-discipline collaborations (e.g., between biologists with different specializations), short distance within the same super-discipline (e.g., an engineer collaborating with a biologist), and long-distance across distinct super-disciplines (e.g., an ecologist working with a social scientist). Team J is interdisciplinary.

Team Resilience Results

Knowledge Of Network

Convergence is the depth of interdisciplinary integration.

Disparity of understanding for Clinical Professor and Assistant Professor indicates opportunities for learning.



	Total Degree	In Degree	Out Degree	Betweenness
Clinical_Professor 1	1	1	1	0.0
Professor 1	3	3	2	5.0
Professor * 2	2	2	2	0.5
Professor 3	2	2	4	6.5
Assistant_Professor 1	2	2	1	0.0

Knowledge Of Network Visualized

Critical realism: philosophical approach aiding in communication.

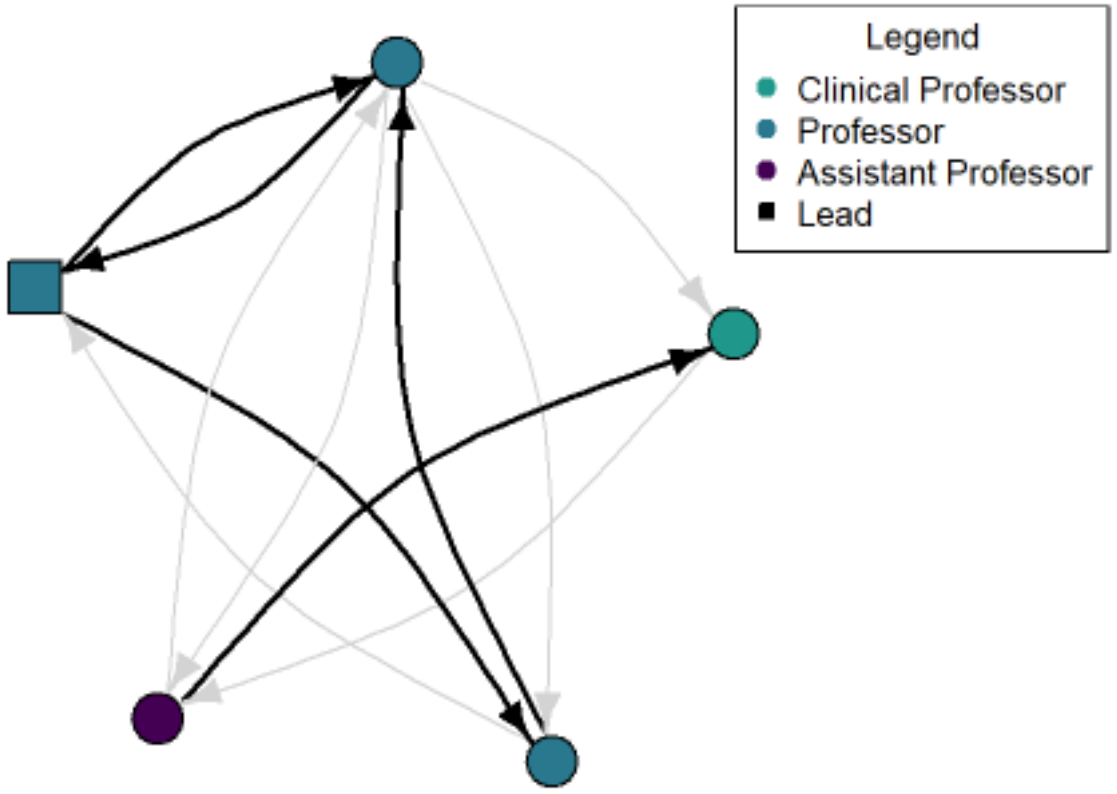
Knowledge Of Network Centrality Box Plots

The out-degree reflects individuals' awareness levels of other team members' discipline, serving as a crucial indicator of the team's capacity for producing convergent research.

Team Resilience Results

Personal Network

Team J shows balanced, widespread personal connections suggesting a cohesive and stable team.



	Total Degree	In Degree	Out Degree
Clinical_Professor 1	2	2	2
Professor 1	2	2	2
Professor * 2	2	2	1
Professor 3	3	3	4
Assistant_Professor 1	2	2	2

Total degree indicates the overall level of a member's connections, in-degree shows how often a member is sought out, and out-degree reflects a member's outreach.

LOVE

Team Resilience

Future Research

- Investigating the evolution of mentor-mentee relationships.
- Network treatments reconfigure existing structures increase connectivity, interdisciplinary collaboration, and mitigate biases.

  Determine possible connections for network treatment.

Conclusions

- Discrepancy in the recognition of mentoring roles within the team.
- Team J has well-established researchers suggesting a need for mentee team members.
- Team J is super-distance interdisciplinary.

LOVE

Scientific Productivity

Research Questions

- What is the nature of collaborative relationships between team members when the team is formed?
- What are the network approaches to evaluate research team productivity?

Hypotheses

- Historical grant proposal network tells of collaborative grant proposal experience.
- Understanding How network predicts a team's ability to co-create.
- Professional networks provide a baseline to compare changes in team productivity.

Measuring Scientific Productivity

Hypothesis 2: Scholarly work history can be measured using SNA methods.

Historical Grant Proposals

What experience do team members have in collaborating on grant proposals?

Understanding How

Gauges team members' perceptions of how their colleagues' methods will contribute towards creating collective scholarly work.

Professional Networks

What are the previous mentoring and advice relationships among team members?

Measures the baseline for which future research can compare.

Scientific Productivity Results

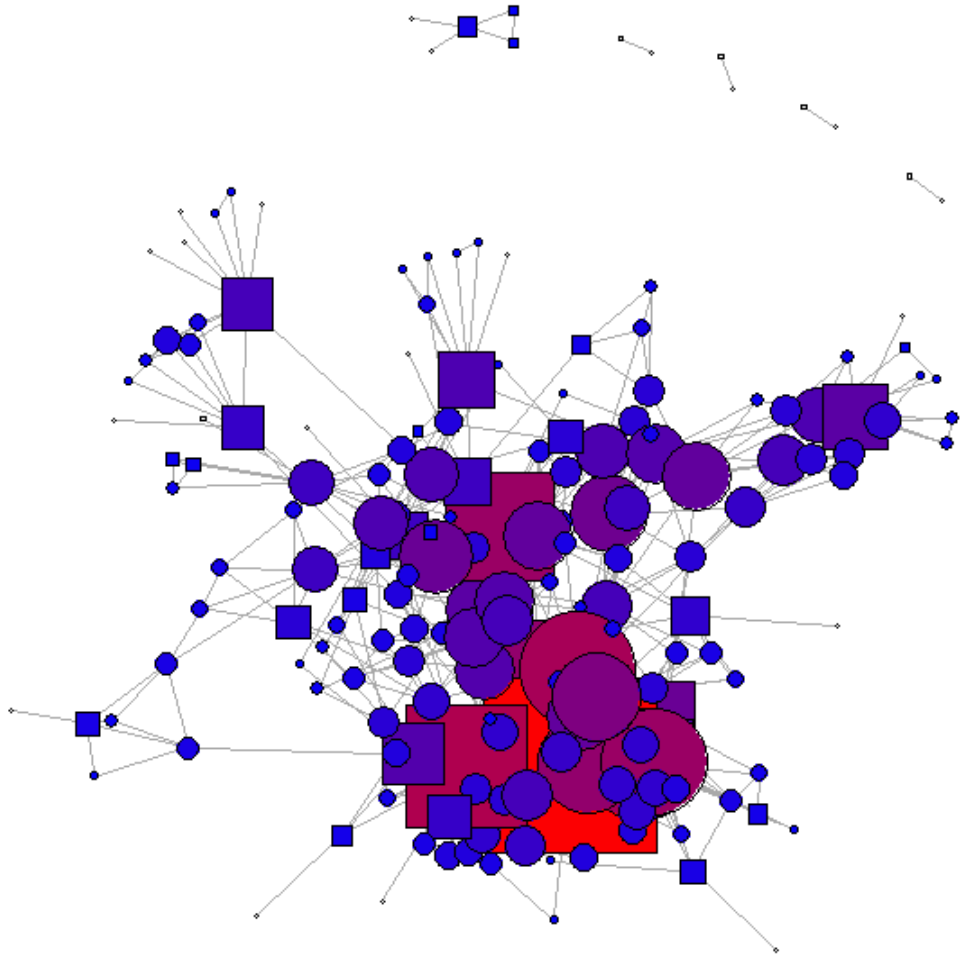
Historical grant proposal network

Clinical Professor did not collaborate on a grant proposal between 2016 and 2020.

Professor 2 is highly experienced collaborating on grant proposals.

Table

Lead	Position	PI	Degree	Betweenness	Proposal Count	Proposal Quartile
FALSE	Clinical Professor	FALSE	0	0.0	NA	NA
FALSE	Professor 1	TRUE	4	368.0	2	2
TRUE	Professor 2	TRUE	13	1742.4	8	4
FALSE	Professor 3	TRUE	1	0.0	1	1
FALSE	Assistant Professor	TRUE	3	0.0	2	2

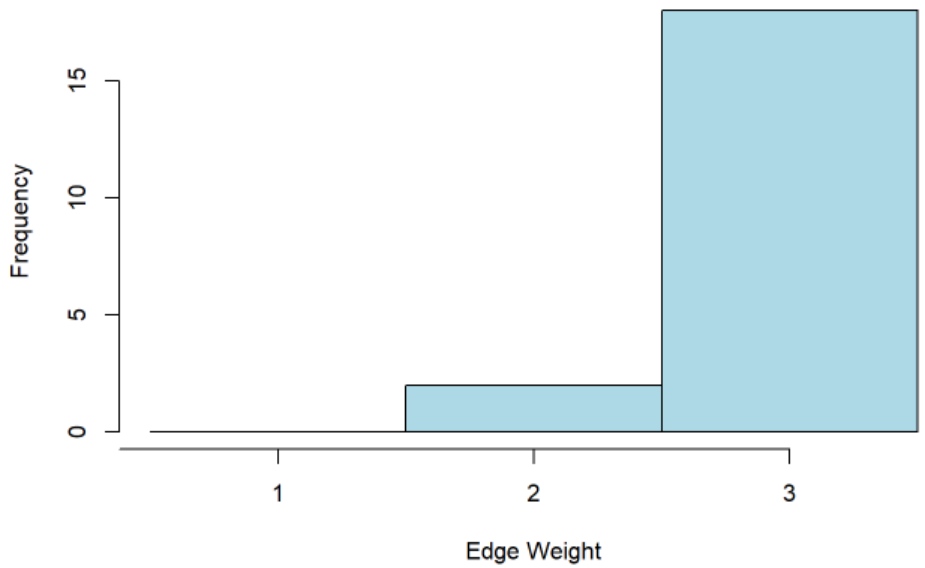


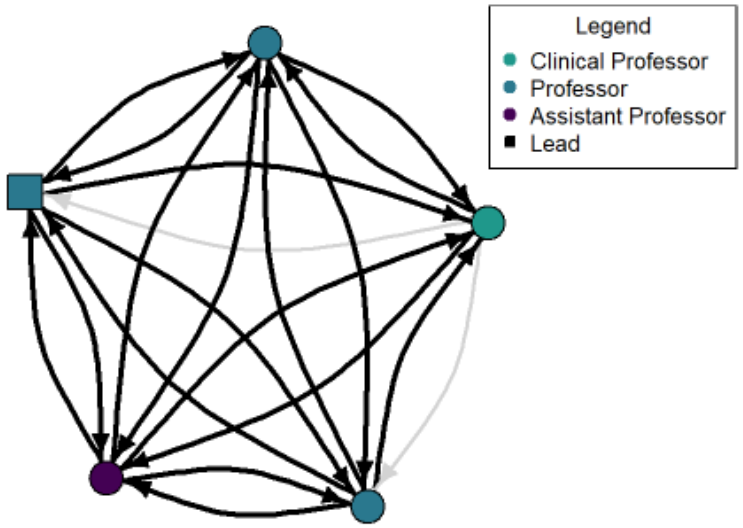
All GCs teams' members (square) and their collaborators. Node size and color indicate the degree, with larger, redder nodes indicating more frequent collaboration.

Scientific Productivity Results

Understanding How Network

Predicts a team's ability to co-create.





Edge Weight Distribution

Team J has a remarkable understanding of how their colleagues' methods will contribute to creating collective scholarly work.

A risk of interviewer demand effects where the team's strategic planning sessions around the time survey was launched.

Understanding How Network for Team J

Network plot is completely realized.

Professional Networks

This absence or minimal presence of connections may indicate that the team is in the early stages of establishing new network connections, reflecting a phase of developing collaborative interactions.

University Business and Grant Proposal networks are analyzed independently.

All networks are analyzed for similarity of connections.

Scientific Productivity Results

University Business and Grant Proposal Networks

Pre-team formation creative work provide a baseline for future analyses.

	Total Degree	In Degree	Out Degree	Betweenness
Clinical_Professor 1	1	1	4	0.0
Professor 1	4	4	2	4.0
Professor * 2	2	2	4	3.5
Professor 3	4	4	2	0.5
Assistant_Professor 1	3	3	2	0.0

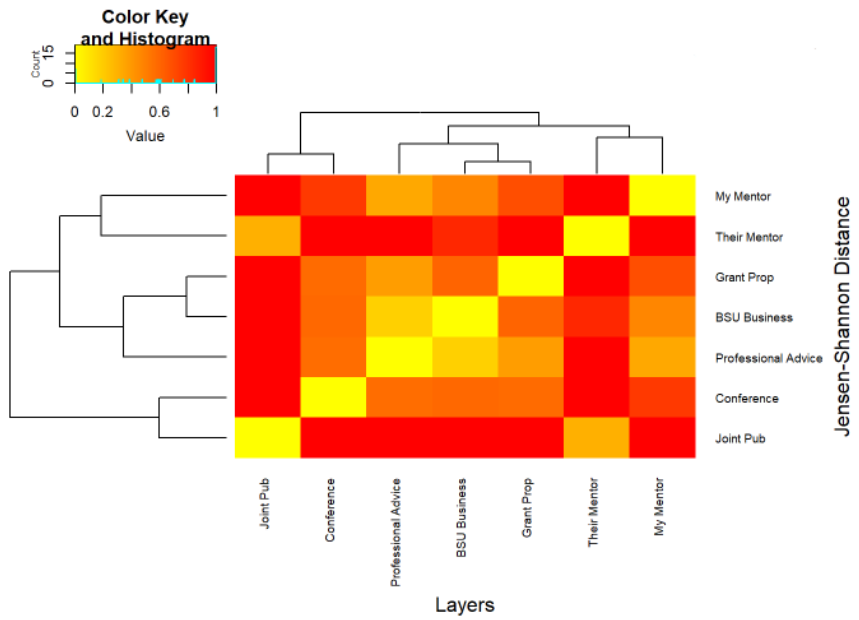
	Total Degree	In Degree	Out Degree	Betweenness
Clinical_Professor 1	1	1	2	0
Professor 1	0	0	1	0
Professor * 2	4	4	1	3
Professor 3	1	1	1	0
Assistant_Professor 1	1	1	2	0

University Business Table

Showcases a high degree of collaboration and mutual recognition among members, particularly Professor 1 and Professor 3, indicating a robust framework for university-related activities.

Grant Proposal Table

Shows a selective pattern of engagement, with Professor 2 playing a central role in collaborations. Despite its lower density, this network offers insight into the potential for enhancing grant-seeking activities.



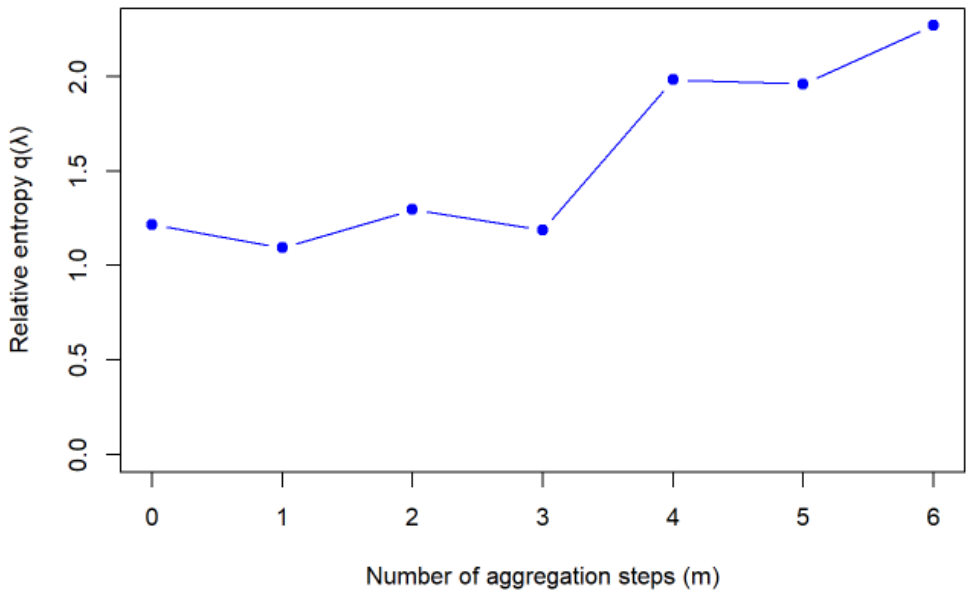
Scientific Productivity Results

Professional Network

Specific professional networks will exhibit significant coupling.

Ties in one network can predict ties in another network.

Aggregation	Components_Merged	JSD
Aggregation 1	University Business + Professional Advice	0.1849
Aggregation 2	Their Mentor + Joint Publication	0.3113
Aggregation 3	My Mentor + Aggregation 1	0.3944
Aggregation 4	Grant Proposal + Aggregation 2	0.4718
Aggregation 5	Conference + Aggregation 3	0.5786
Professional	Aggregation 4 + Aggregation 2	0.9380



LOVE

Scientific Productivity

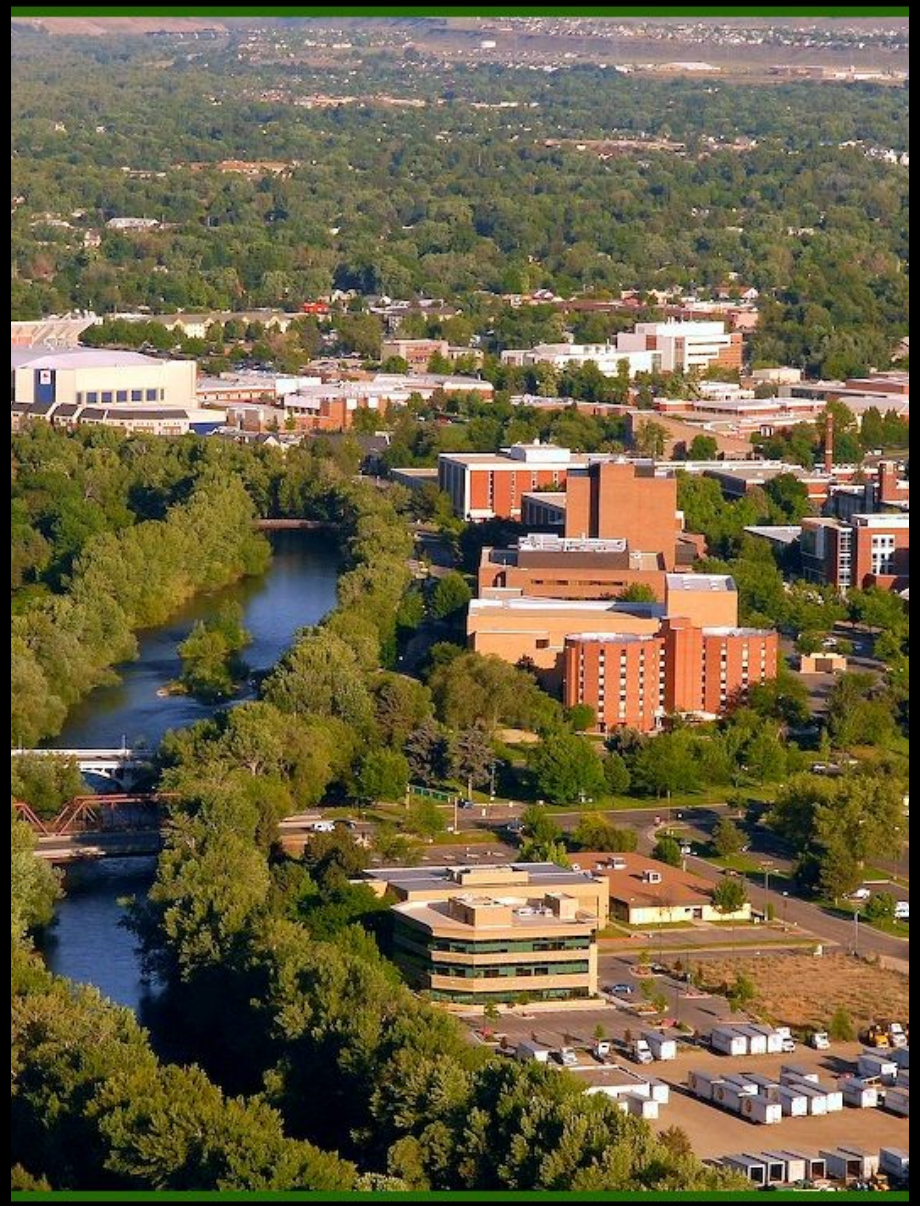
Future Research

- Repeat surveys annually to explore changes in these network metrics.
- Power Graphs, as introduced by Panagopoulos et al. (2017), quantify the creative output of research groups
- Investigate the association between mentoring and advice networks research productivity.

(LOVE et al., 2021)

Conclusions

- Historical grant proposal network may tell of collaborative grant proposal experience.
- Understanding How network may predict a team's ability to co-create.
- Professional networks provide a baseline to compare changes in team productivity



Conclusion of presentaiton

This detailed analysis of the socio-relational structures and institutional context provides insights into interdisciplinary collaboration at the dawn of the Grand Challenges initiative.

The Grand Challenges initiative at Boise State promotes transdisciplinary, innovative research. By bringing together experts across disciplines, the university is addressing wicked problems.

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Questions?

What questions do you have about the presentation?

Are there any unclear points you'd like me to elaborate on?

I'm happy to take questions by email

lorrainegaudio@u.boisestate.edu

Please feel free to ask any questions you may have about the presentation content.