The RCN (Research Coordination Network) experiment: Can we build new research networks?

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Abstract

The U.S. National Science Foundation Research Coordination Network (RCN) program broke new ground in funding the development of new research communities of practice. This assessment of RCN supports the conclusion that networking activity was increased for a sample set of projects compared to a control group. Journal articles resulting from RCN support score as highly interdisciplinary. Moreover, those articles appear as notably influential, being published in high impact journals and being highly cited. The RCN program does indeed seem to be fostering new biological science research networks.

The U.S. National Science Foundation ("**NSF**") Biology Directorate instigated the Research Coordination Network ("**RCN**") Program in 2000 to:

> "…foster communication and promote collaboration among scientists with common interests from a broad background across disciplinary, geographical, and organizational boundaries."

RCN differs from most NSF core research programs in that funding does not support research per se, but rather supports networking among scientists not already collectively collaborating. It seeks to catalyze development of research areas at the shared margins of more conventional fields. Specifically, "proposed networking activities directed to the RCN program should focus on a theme to give coherence to the collaboration, such as a broad research question or particular technologies or approaches" (www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf11001).

The goal of this analysis was to gauge the effects of RCN support on fostering interdisciplinary research and publication. We focused on detecting changes in research networking. Secondary interests entailed locating RCN researchers' work among the disciplines, measuring how interdisciplinary their articles were, and exploring utilization of their results.

Data and Methods

The study seeks to identify changes in the behavior of groups of NSF-funded researchers from "Before to After" their RCN awards. The 13 RCN projects that constitute our study sample were initiated between January, 2001, and March, 2003 (Appendix 1). We selected 5 unfunded RCN proposals as a comparison group ("**CompGrp**") to check whether observed changes are likely due to underlying environmental or maturational changes, or not (a sixth group had to be excluded from the analyses as it did not have sufficient publications in the Before and After periods). We searched Web of Science ("**WOS**") to gather abstract records for publications by the RCN and CompGrp core participants in the proposal and for RCN participants identified in

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project reports. We selected 1999-2001 as the "Before" period and 2006-08 as "After," given that the awards are for 5 years.

NSF colleagues perused the RCN final reports to identify publications attributed to this NSF support. We report on separate analyses on these as "RCN-derived." We also searched WOS for publications that cite these RCN and CompGrp papers. Appendices 2 & 3 provide a tally. A companion article (Garner et al., under submission) reports on the data, metrics, and processes in more detail.

Findings

***Collaboration*:** The extent of co-authoring is a direct indicator of research networking. Table 1 shows notable increases in co-authoring, cross-institutional collaboration, and international collaboration. However, the comparison (control) group also shows increased collaboration.

Table 1. Collaboration [See Appendix 3 for numbers of articles in each category]

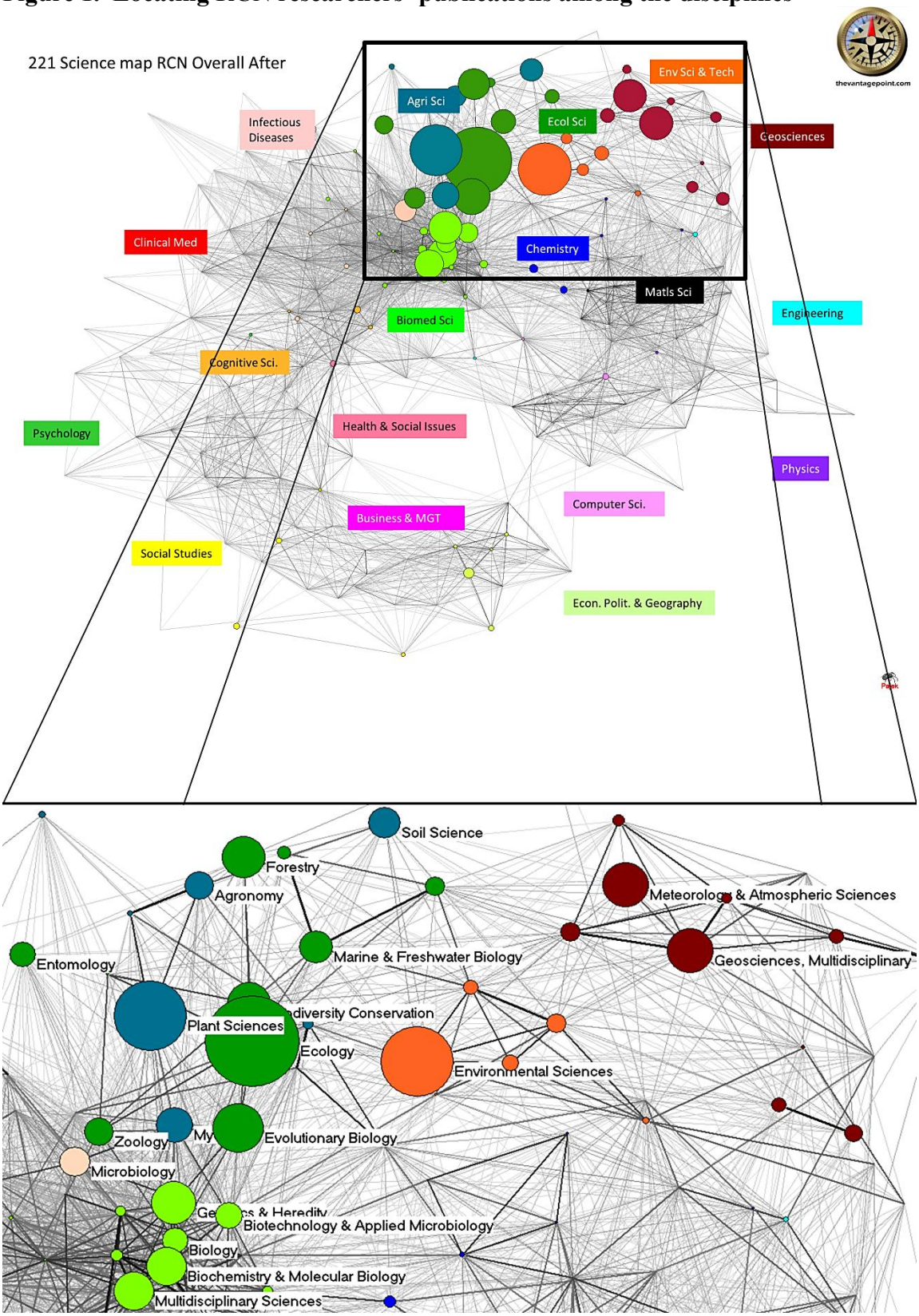
	RCN		**Comparison Group**	
	Before	**After**	**Before**	**After**
Authors/Paper	4.46	5.66	3.96	5.04
Institutions/Paper	2.43	3.17	2.03	2.66
Countries/Paper	1.51	1.85	1.29	1.54

Garner et al. (under submission) present within-project, Before-vs.-After comparisons for these collaboration measures (like Figure 2's project comparisons on another variable). Paired t-tests find that the increase in authors, institutions, and countries per paper is highly significant for the 13 RCN groups ($p < 0.001$), but not significant for the 5 Comparison groups on any of these three measures.

Citing one another's work is an alternative indicator of effective networking. It may well be that two members of a research network interchange ideas, but don't co-author. To further explore this, we examined the extent of cross-citation within each RCN and comparison group. Cross-citation increased from Before to After for 8 of 13 RCNs, versus only 1 of 5 comparison groups. Collectively, for RCN-funded projects, the number of within-network links increased from 1124 to 1303 (16%).

Engaging Multiple Disciplines: WOS groups journals into "Subject Categories" (some 221 covering the sciences and social sciences). We use these to reflect disciplinary involvement. Figure 1 presents a "science overlay map" (Leydesdorff and Rafols, 2009; Porter and Rafols, 2009; Rafols et al., 2010; Rafols and Meyer, 2010) locating the RCN "After" publications among the disciplines. This indicates wide engagement of the biosciences by this NSF program. The RCN "Before," and CompGrp profiles are similar, suggesting that the CompGrp provides a reasonable comparison in this respect.

Figure 1. Locating RCN researchers' publications among the disciplines[2]

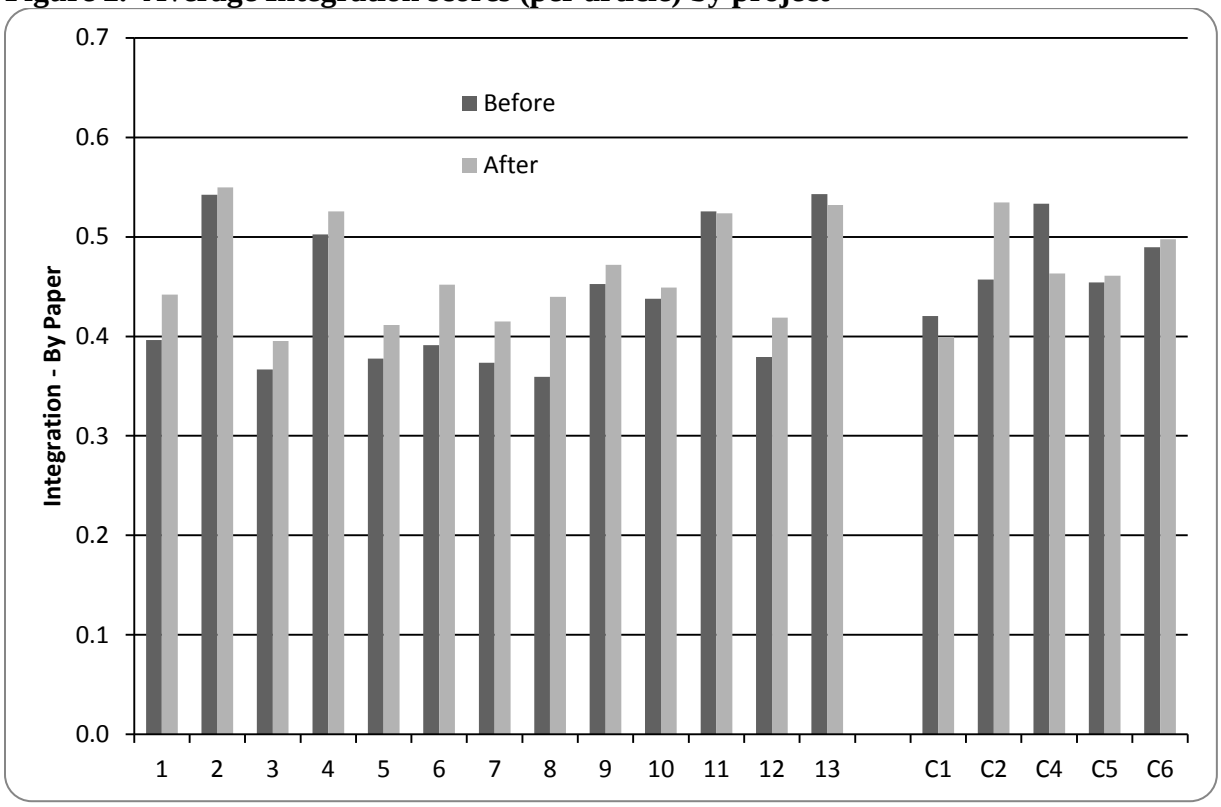


[2] The gray background intersections are the 221 Subject Categories. They are located based on cross-citation relationships among all WOS journals in 2007. The 18 labeled "macro-disciplines" are based on factor analyses of that cross-citation matrix as well. Nearness in the map indicates closer relationship. The circular node sizes reflect the number of RCN researcher publications.

***Interdisciplinarity*:** The main indicator we use to gauge this is an "Integration Score" devised to help evaluate the National Academies Keck Futures Initiative (www.keckfutures.org) to promote interdisciplinarity. This gets at intellectual integration (National Academies Committee on Facilitating Interdisciplinary Research, 2005, p. 188) by measuring the diversity (Stirling 2007) of the references cited by a given paper (or compilation) (Porter et al. 2008). Integration scores range from 0 (all references to the same Subject Category) to 1 (extremely disparate Subject Categories being cited).

Figure 2 compares Integration Scores, Before vs. After, for each RCN and CompGrp project. We see an increase in Integration score, Before to After, for 11 of 13 RCN projects; likewise, for 3 of 5 Comparison groups. Paired comparison t-tests for the 13 RCN projects, Before vs. After, indicate that the increase in Integration per paper is significant ($p = 0.0013$), whereas that for the Comparison group is not ($p = 0.99$).

Figure 2. Average Integration scores (per article) by project



If instead of calculating Integration for each paper, and then averaging by project, we calculate a single Integration Score based on all the references by a given project's researchers in a period, the differences are no longer significant. Our interpretation is that at the project level, the collective research knowledge of these researchers (as reflected by their referencing patterns) did not change from Before to After RCN support. However, through enhanced networking and intellectual interchange, the diversity of resources drawn upon by a given paper increased (modestly, but statistically significantly).

We have developed benchmark Integration Scores for samples of about 1000 articles in six Subject Categories for 1975, 1985, 1995, and 2005 (Porter and Rafols 2009). Those show a small rate of increase over time. For 2005, the average Integration Score for five Subject

Categories is 0.43; the sixth (Math) is notably lower, 0.20. The RCN-After Integration scores (per paper) average 0.48 – more interdisciplinary than those benchmark papers.

We probed further to explore the degree of Integration per paper, by discipline. We chose sets of RCN-After papers published in six Subject Categories (selected for high publication activity and variety among the categories). We used the benchmark 2005 data for one of those, Biochemistry, and drew random samples from WOS, 2009, for the other five Subject Categories. Figure 3 compares three sets of papers: RCN-Derived (papers noted in the reports to NSF as related); RCN-After papers (excluding those identified as derived); and the unrelated benchmarks.

Figure 3. Benchmarking RCN article Integration scores by Subject Category

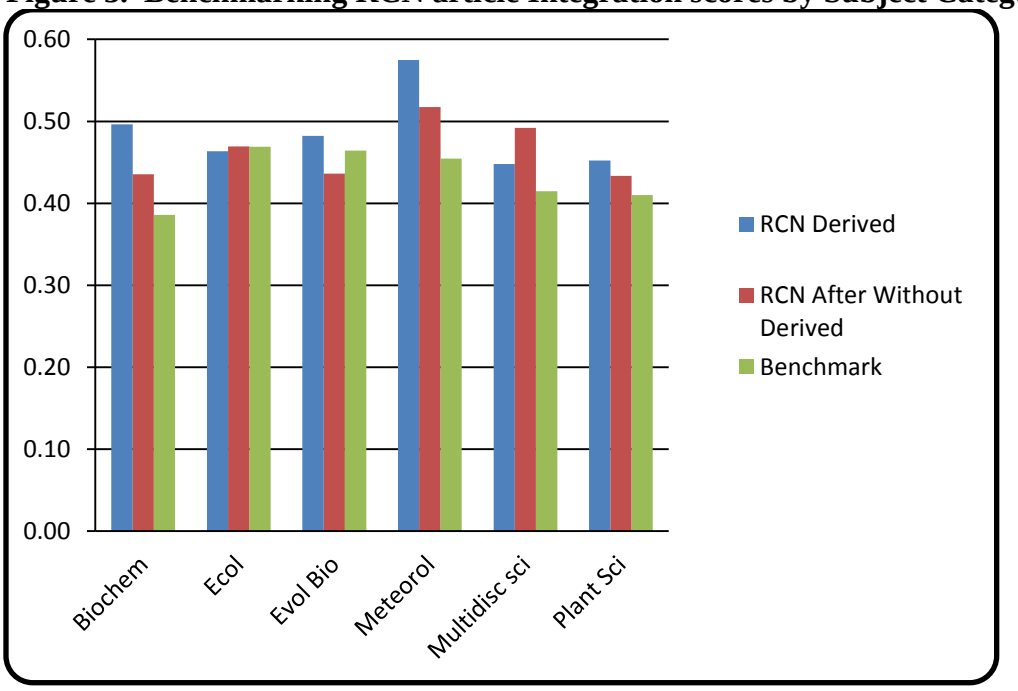


Figure 3 suggests moderate variability in the Integration scores by discipline, for these RCN-pertinent Subject Categories. RCN-Derived Integration scores range from a mean of 0.45 for Plant Sciences to 0.58 for Meteorology. In most cases, the RCN-related papers tend to be more interdisciplinary than the randomly selected benchmark papers published in the same Subject Categories.

Research Influence: In this section, we focus further on the "RCN-Derived" papers – i.e., those most related to project support. Table 2 presents statistics comparing the various sets of publications. "Times Cited" provides one (imperfect) measure of research influence. In that citations tend to accrue over time, we use Times Cited per Year to normalize for the unequal time since publication. This shows that the RCN-Derived papers have been cited more on average. "Journal Impact Factor" provides an indicator of journal quality (based on the extent to

which a journal's articles tend to be cited by others). Again, this shows the most RCN-related research to be strongest.[3]

Table 2. Article influence

	# of Articles	Times Cited per Year	Journal Impact Factor	% of Papers cited > 10X per year
RCN Before	1599	4.4	4.3	7.54%
RCN-Derived	**235**	**7.0**	**6.1**	**18.30%**
RCN After (without Derived)	2039	2.0	4.0	2.55%
Comparison group Before	173	3.1	3.7	3.80%
Comparison group After	197	2.1	3.3	1.69%

The last column of Table 2 offers another metric. Instead of looking at averages (citations generally show highly skewed distributions), here we look at the percentage that are very highly cited. Again, the RCN-Derived papers stand forth boldly. To give the flavor of this RCN-instigated research, the five most cited range from 506 to 197 cites received to date -- (Chanson et al. 2004, Ainsworth and Long 2005, Bustamante et al. 2006, Alice et al. 2003, Arnold et al. 2004).

Discussion

RCN engages a generous swath of bio- and environmental science disciplines. Figure 2 maps the distribution of RCN-After publications over a map of science.

We see good evidence that RCN support leads to enhanced networking among participating researchers. By various indicators, we see that within-project connectedness goes up from Before to After award for most of the RCN projects. The statistical measure of "average degree" shows an increase in co-authoring network density for the 13 projects approaching statistical significance ($p = 0.07$).

RCN support appears to foster more interdisciplinary research. The set of articles attributed most closely to RCN support scored as especially interdisciplinary. Additional evidence is that the diversity of references cited by RCN-After papers exceeds that of RCN-Before (i.e., higher Integration score).

An interesting finding is that if we generate Integration scores for the collective set of papers associated with a project, this does not increase from Before to After. Our Specialization scores (tapping breadth of publication SCs) reinforce this finding in that they stay the same from Before to After (detailed in Garner et al., under submission). Our interpretation is that the sum total of research fields engaged by a given set of researchers participating in an RCN does not, and should not be expected to, increase. Research networking is meant to focus on shared interests, bringing together diverse perspectives, knowledge, and skills – not to cause the group to redirect its interests "outside."

[3] t statistics show that the RCN-Derived sets are significantly higher than the RCN-Before and RCN-After sets, on each measure.

We found that the articles most related to RCN project activities were especially influential. They tend to appear in high impact journals and also to be highly cited.

In sum, the RCN program appears to be "changing the way bioscience is done." That is, not in a paradigm-breaking way, but by fostering new research networks. This is an exciting way to facilitate interdisciplinary research to address especially complex and challenging natural issues. Perhaps the notion of supporting Research Coordination Networks could extend effectively to societal, technological, and other challenges as well.

Acknowledgements

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Appendices

1. Research Cooperation Networks (RCN) projects Studied

Project	Title	NSF Program
1	Terrestrial Ecosystem Response to Atmospheric and Climatic Change	Ecosystem Studies
2	A Phylogeny for Kingdom Fungi	Phylogenetic Systematics
3	Wolbachia Reseach Coordination Network	Population Dynamics
4	Biosphere-Atmosphere Stable Isotope Network	Ecosystem Studies
5	Deep Green: Toward an Integration of Plant Phylogenetics and Plant Genomics	Phylogenetic Systematics
6	Deep Time: A Comprehensive Phylogenetic Tree of Living and Fossil Angiosperms	Phylogenetic Systematics
7	Comparative Demographic Analyses Using a Global Network of Large Plots	Population and Community Ecology
8	Coordinated Research on Amphibian Population Declines in the Neotropics	Population Dynamics
9	The North Atlantic Project: Historical Ecology of the Trans-Atlantic Biotia	Phylogenetic Systematics
10	Biodiversity Mechanisms of Ecosystem Regulation in the Global Environment	Ecosystem Studies
11	Chequamegon Ecosystem-Atmosphere Study	Ecosystem Studies
12	Molecular and Organismic Research in Plant History	Population Dynamics
13	ARIDnet for the Americas: A Research Network for Testing New Paradigms for Global Desertification	Ecosystem Studies

2. **Researchers and research outputs compared**

	RCN		Comparison Group	
	Range	**Average**	**Range**	**Average**
BEFORE (1999-2001)				
# of Articles/project group	37 to 218	140	20 to 68	37
# of Researchers publishing/project group	4 to 36	18	3 to 9	6
AFTER (2006-2008)				
# of Articles/project group	43 to 440	179	24 to 96	47
# of Researchers publishing/project group	6 to 36	20	3 to 10	6

3. Research publications and citations

	RCN		Comparison Group	
	Before	**After**	**Before**	**After**
Authors/Paper	4.46	5.66	3.96	5.04
Institutions/Paper	2.43	3.17	2.03	2.66
Countries/Paper	1.51	1.85	1.29	1.54