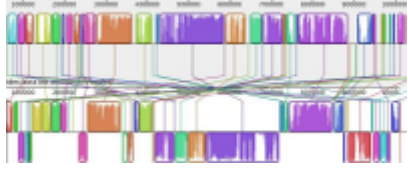


# **A Comparison of Social Science Research in Synthetic Biology and Nanotechnology**

Jan Youtie, Philip Shapira  
Global Tech Mining, Leiden,  
September 2014

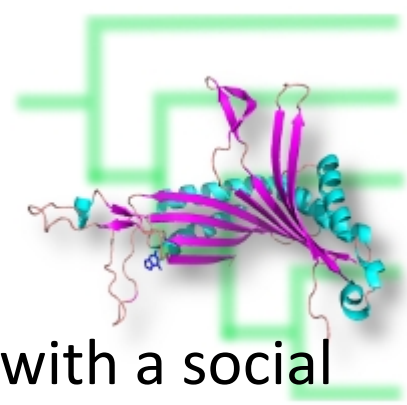
# Overview

- ***Where and how do social scientists participate in emerging technologies? Where should they participate?***
- Literature
  - Rise in ELSI work in emerging technologies (2005)
  - But maybe suboptimal
    - Social science research is transdisciplinary (Hicks 2005)
    - ELSI researchers do not collaborate (Shumpert et al 2014)
    - But Guston and Sarewitz (2002) existence of a set of social science methodologies (Real Time Technology Assessment) that cut across emerging technologies
    - Can we have an ELSI trading zone (Gorman 2002)?
    - What types of knowledge are more easily traded/shared? Where are the gaps in ELSI knowledge flows?
- ***Research question → To what extent is there sharing of knowledge base for ELSI research***
  - ***Specifically: do synbio ELSI researchers share knowledge base of nano ELSI?***
  - ***And how can text mining inform this question?***



[www.gauchergroup.biology.gatech.edu/](http://www.gauchergroup.biology.gatech.edu/)

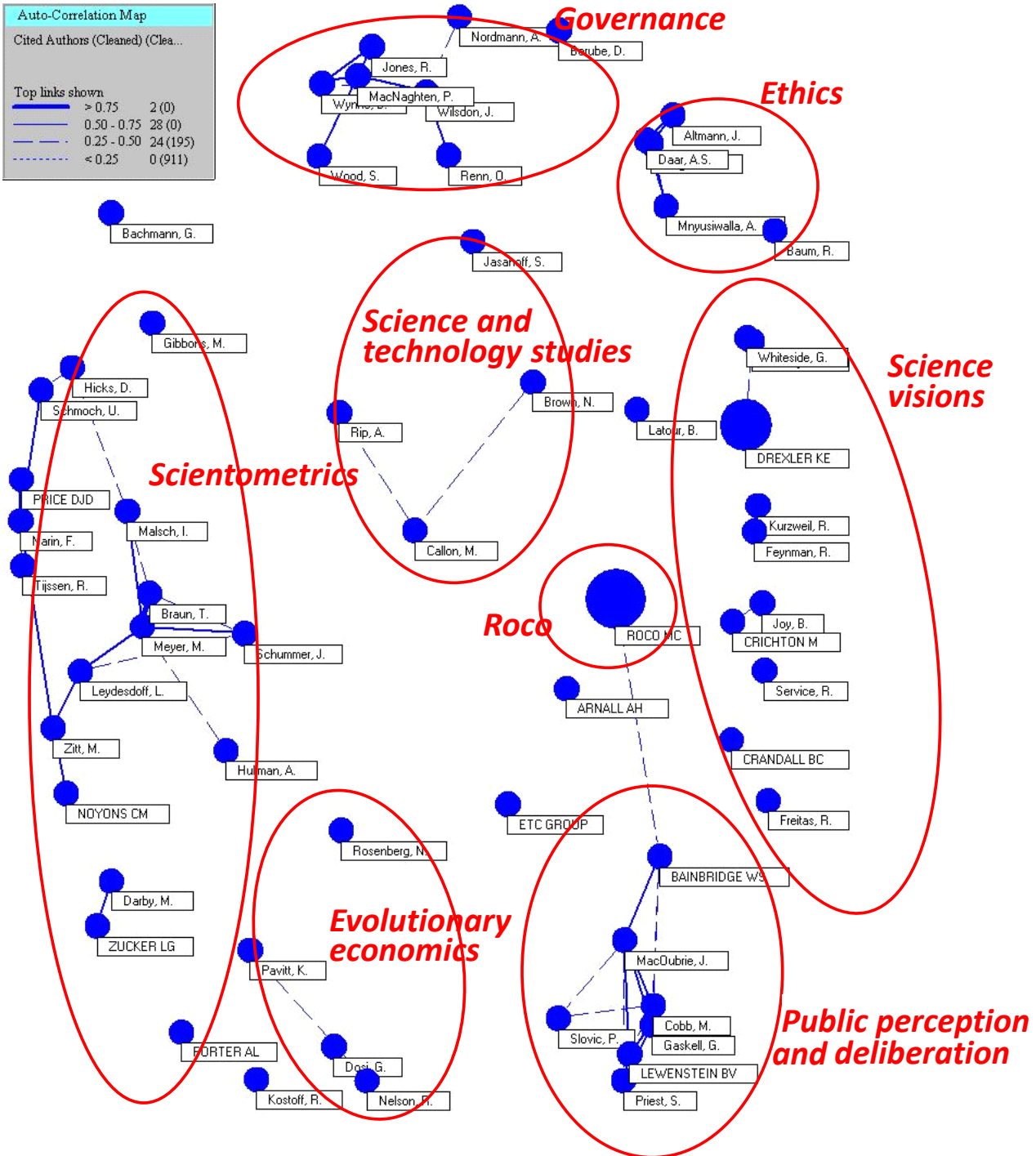
# *Synbio and Nano: Different pre-contexts*



- Synbio is one of the next emerging technologies with a social science focus (after nanotechnology)
- Albeit with differences
  - Synbio
    - Extension from human genomics
    - Transdisciplinary centers (medicine, law, ethics)
  - Nanotechnology
    - No prior infrastructure
    - 21<sup>st</sup> Century Nanotechnology R&D Act created ELSI research agenda
    - NSF created separate centers
- Both are post GMO where a quantum leap in thinking about ELSI occurred
- Acknowledging these differences, we focus on the knowledge bases as measured by cited references

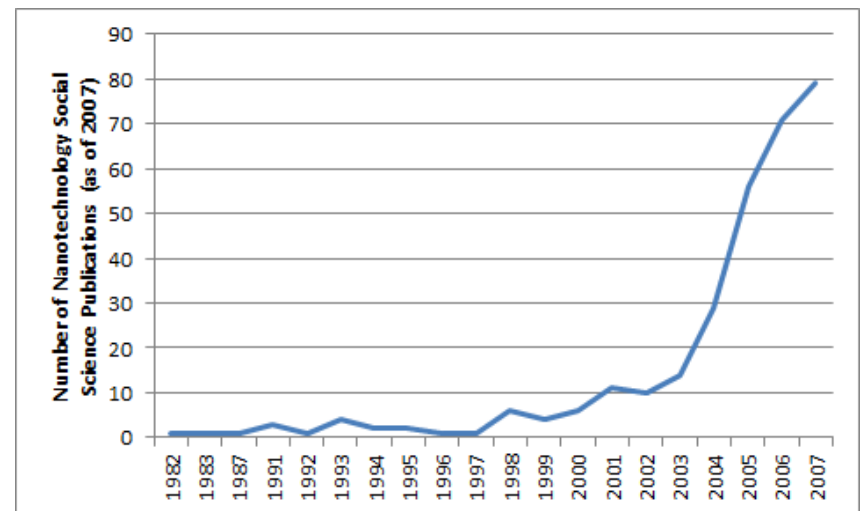
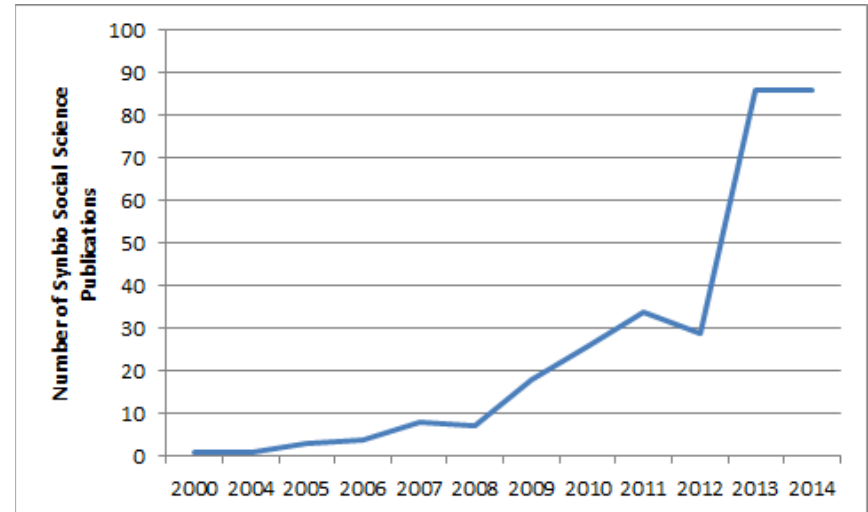
For replication:  
Nano Reference  
Dimensions

Auto-Correlation Map		
Cited Authors (Cleaned) (Clea...		
Top links shown		
	> 0.75	2 (0)
	0.50 - 0.75	28 (0)
	0.25 - 0.50	24 (195)
	< 0.25	0 (911)



# Data

- Synbio social science articles
  - 314 articles from WOS SSCI/AHCI
  - Scopus “Social Science and Humanities” (less *Science*, *Nature*, *PNAS*)
  - Merged files, kept WOS records where duplicates existed
- Comparison with 308 articles, same sources, earlier study of nanotechnology in the social sciences (Shapira et al., 2010)
- Synbio ~ Shapira study nano phase
  - 10x growth in first wave (2009-11), 3x growth in second (2012-13)



# *Different Cast of Characters: Most Cited Synbio Social Science Papers*

Author	Cited	Article
Allarakhia M, Walsh S	25	Managing knowledge assets under conditions of radical change. <i>Technovation</i> , 2010
Reichman J, Dreyfuss R	22	Harmonization without consensus, <i>Duke Law Journal</i> , 2007
Miller S, Selgelid M	20	Ethical and philosophical consideration of the dual-use dilemma in the biological sciences, <i>Science and Engineering Ethics</i> , 2007
O'Malley M, Calvert J, Dupre J	17	The study of socioethical issues in systems biology, <i>American Journal of Bioethics</i> , 2007
Calvert J	16	The Commodification of Emergence, <i>Biosocieties</i> , 2008
Calvert J, Fujimura J	16	Calculating life, <i>Studies in History and Philosophy of Science Part C</i> , 2011

# *Different Cast of Characters: Most Cited Nano Social Science Papers (as of 2008)*

Author	Cited	Article
Meyer, M	55	Does science push technology? <i>Research Policy</i> , 2000
Meyer, M	22	Patent citations in a novel field of technology, <i>Scientometrics</i> , 2000
Schummer, J	22	Multidisciplinarity, interdisciplinarity, and patterns of research collaboration in nanoscience and nanotechnology, <i>Scientometrics</i> , 2004
Persson, O, Meyer, M	21	Nanotechnology—interdisciplinarity, patterns of collaboration and differences in application, <i>Scientometrics</i> , 1998
Braun T, Schubert A, Zsindely S	20	Nanoscience and nanotechnology on the balance, <i>Scientometrics</i> , 1997

# *Focus Cited References*





- 7200+ cited references
- Cited reference cleaning
  - Person name fuzzy list cleanup algorithm
- Multi-dimensional scaling (MDS) analysis of co-citations of all authors with more than 15 mentions in these papers in VantagePoint (40 authors)
  - Nodes = # papers citing work by authors
  - Links = degree of association in being cited by two or more papers, VP path-erasing algorithm focuses on strongest links
  - Multiple dimensions reduced into two-dimensional space, proximity of nodes indicates association
- Categorization/labeling/interpretation based on education, current research

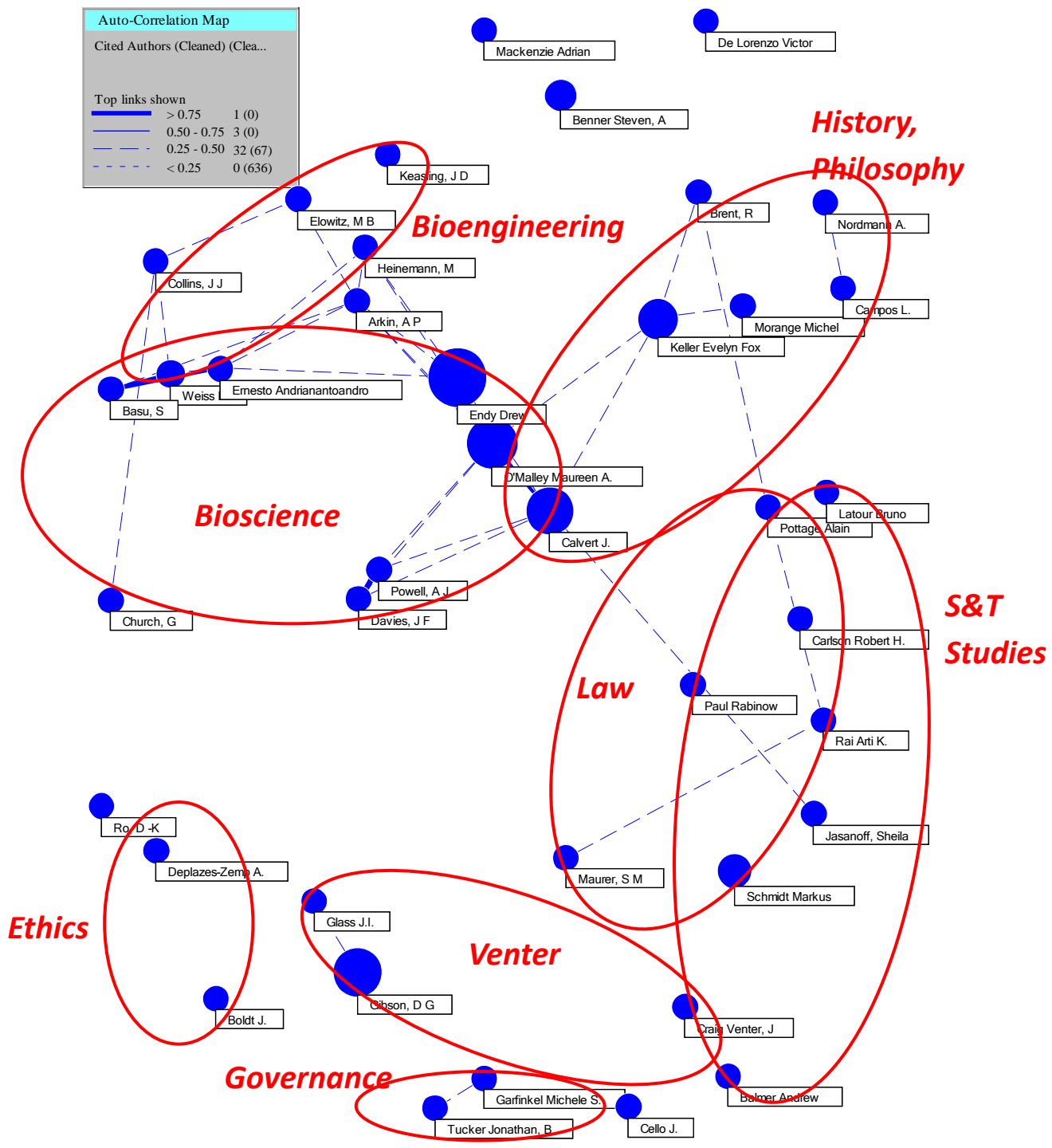


# Top 10 authors in References

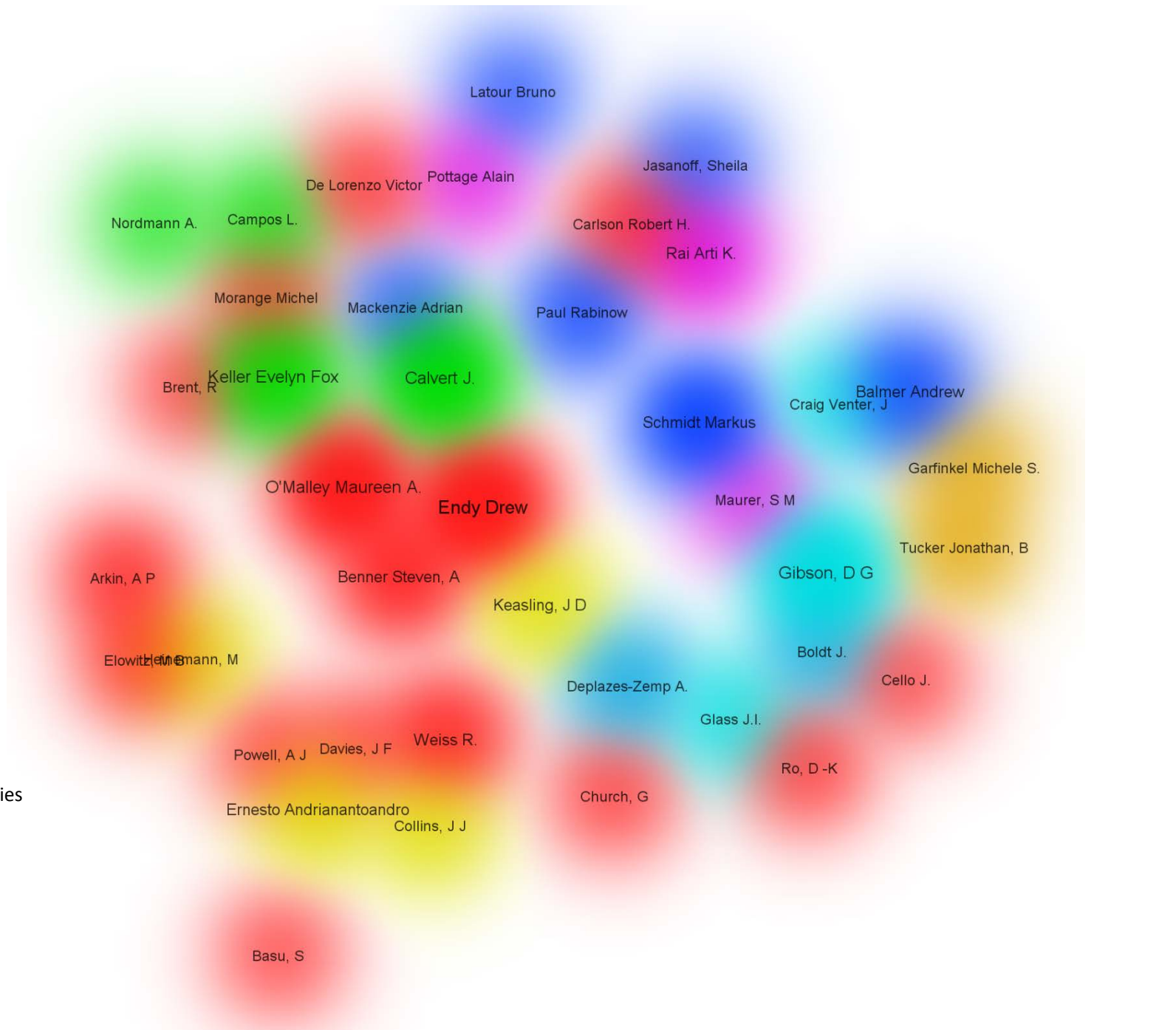
Author	Citing	Key Paper(s)
Endy	70	Foundations for engineering biology, 2005, Nature
O'Malley	61	Knowledge-making distinctions in synthetic biology, 2008, Bioessays
Gibson	58	Creation of a bacterial cell controlled by a chemically synthesized genome, 2010, Science
<i>Calvert</i>	<i>57</i>	<i>The role of social scientists in synthetic biology, 2009, EMBO Rep</i>
<i>Keller Fox</i>	<i>48</i>	<i>What does synthetic biology have to do with biology? 2009, Biosocieties</i> <i>The Century of the Gene, 2000</i> <i>Making Sense of Life, 2003, 2009</i>
<i>Schmidt</i>	<i>41</i>	<i>Special issue: societal aspects of synthetic biology 2009, Systems &amp; Synthetic Biology</i> <i>Synthetic biology: The technoscience and its consequences, Springer, 2009</i>
Benner	38	Synthetic Biology, 2005, Nat Rev Genet
Andrian. & Weiss	34	Synthetic biology: New engineering rules for an emerging discipline, 2006, Molecular Systems Biology
<i>Balmer</i>	<i>30</i>	<i>Synthetic Biology: Social and Ethical Challenges, 2008</i>
<i>Rai</i>	<i>29</i>	<i>Synthetic biology: caught between property rights, the public domain, and the commons, 2007, PLoS Biol</i>

Synbio  
Reference  
Dimensions

Auto-Correlation Map		
Cited Authors (Cleaned) (Clea...		
Top links shown		
	> 0.75	1 (0)
	0.50 - 0.75	3 (0)
	0.25 - 0.50	32 (67)
	< 0.25	0 (636)

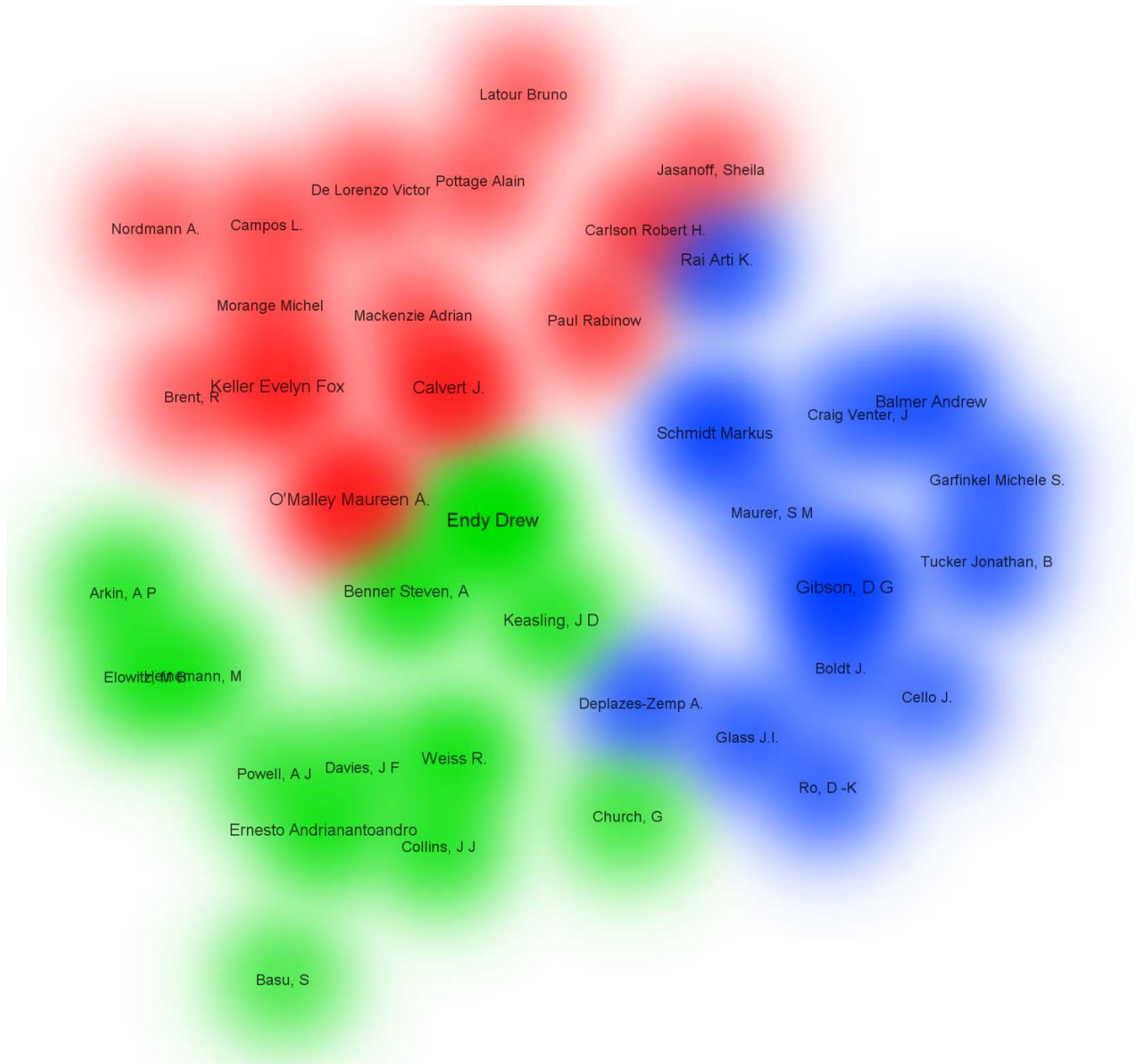


VOSviewer  
 Cluster  
 Density View:  
 Colors  
 represent  
 A Priori  
 Partitions



- A Priori Partitions
- Bioscience
  - Bioengineering
  - Science & Tech. Studies
  - Law
  - History, Philosophy
  - Governance
  - Venter
  - Ethics

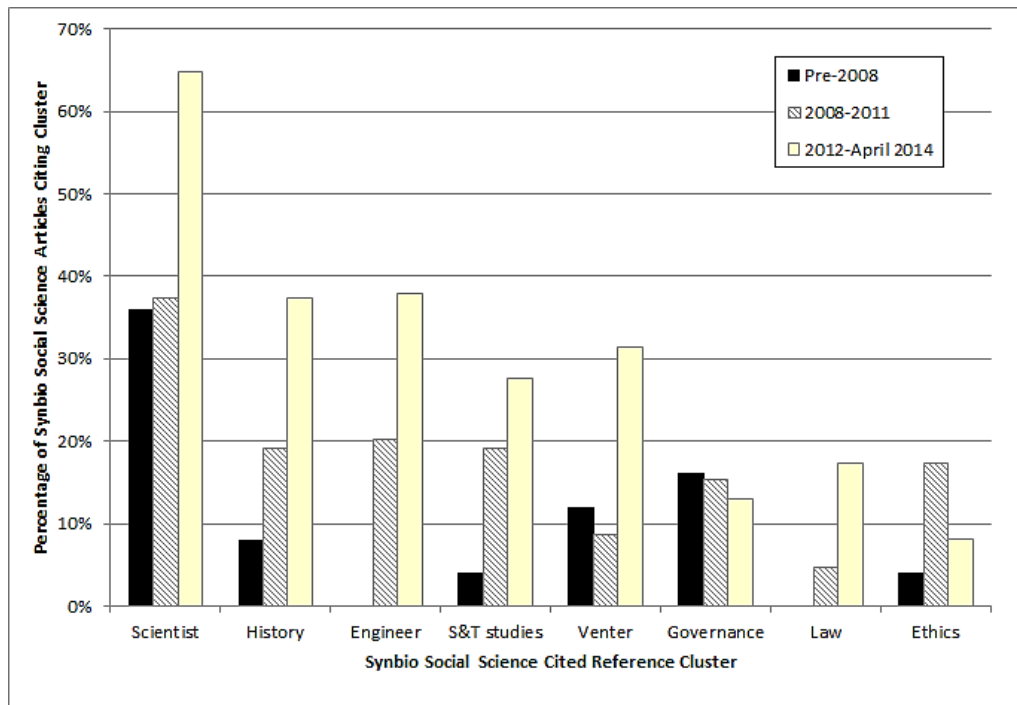
VOSviewer  
Cluster  
Density View  
- 3 cluster  
solution



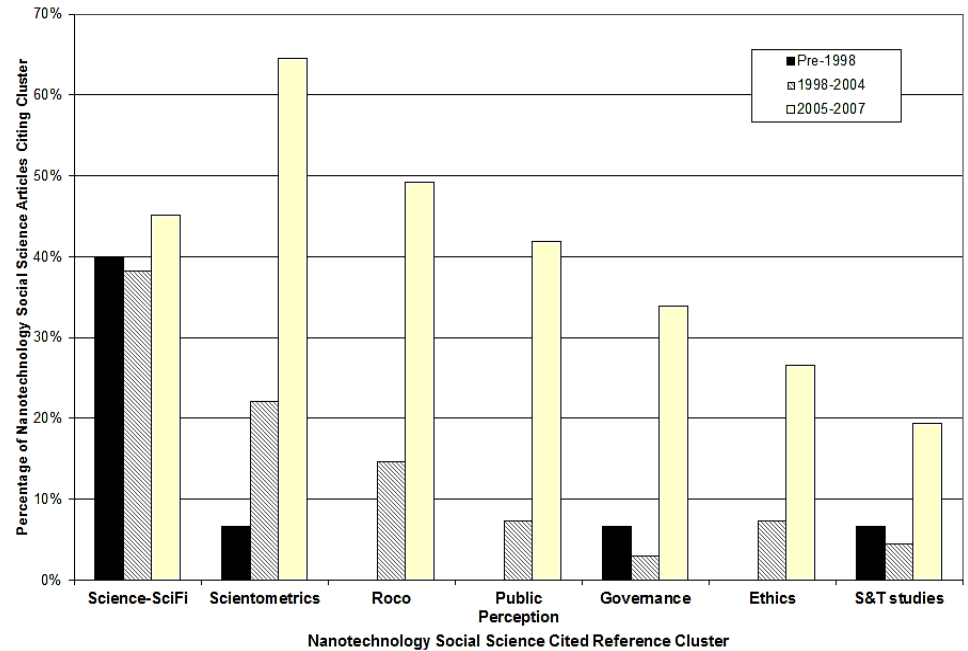
# *Observations from Maps*

- Synbio has overlap between clusters, especially
  - Law
  - STS
- Some researchers are difficult to categorize into a cluster at this point
  - Primarily bioscientists
- VOSviewer map is consistent
  - Except for positioning of bioscientists
  - Provides a 3 cluster solution which reflects the overlaps
    1. Bioscientists/engineers
    2. STS, History and Philosophy
    3. Bioethics, Governance, Venter, Law

## Synbio Reference Dimensions



## Nano Reference Dimensions



# Research Implications

- Back to main research question
  - To what extent is there a shared knowledge base for ELSI research?
  - *Some sharing but some nano social science areas in do not translate to synbio*
- Maybe this is to be expected, given prior observation of lack of sharing across social science disciplines
- New funding may well change actors and knowledge bases
- But it is possible that without attention to missing sub-disciplines, future funding will go to domains as currently organized

# *Acknowledgements*

US National Science Foundation (NSF) through the Center for Nanotechnology in Society (Arizona State University; Award No. 0531194 and No. 0937591). The findings and observations contained in this paper are those of the authors and do not necessarily reflect the views of the US National Science Foundation or the center. Thanks to Yin Li for providing synbio social science data.