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## **Trends in Media Coverage and Information Diffusion over Time: The Case of the American Earth Science Research Center Biosphere 2**

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### **Abstract**

This study examined research center Biosphere 2 (B2) coverage by U.S. newspapers between 1984 (as stories of conception before construction emerged) and 2019 (at the time this research was conducted) in order to uncover news diffusion relative to B2 in public media across historic eras and amid shifts in stakeholders over time. Analysis focused on how a scientific institution and its innovative activities implied values, impacted the meaning-making of its project, as well as influenced the amount of information shared across sources (i.e., regional, metropole, or elite) and media scale (i.e., local, regional, national outlets). Analysis identified nine eras delimited by scientific or organizational events. Findings emerging from this study can inform understandings of media behavior around other scientific institutions and experiments.

*Keywords: Biosphere 2, media coverage, media coverage, science communication, cluster analysis.*

## Introduction

Patterns in news coverage of projects or events can impact how people conceive of them over time. So, this study explores news coverage of Biosphere 2 (B2), a large scientific research center in the Southwestern region of the United States, by examining newspapers between 1984 (as stories of conception before construction emerged) and 2019 (at the time this research was conducted) in order to uncover news diffusion relative to B2 in public media across historic eras and amid shifts in stakeholders over time. In doing so, this study contributes to ongoing conversations about the interrelationships between media and science (e.g., Weingart, P., 1998), the factors that shape attitudes toward science (e.g., Ramsden, 1998), and the impact of news media trends on public attention to scientific issues (e.g., Quesnel and Ajami, 2017; Harmatiy, 2021). Indeed, the information diffused by media about scientific institutions and their activities influence how science is perceived by the public (Brossard and Scheufele, 2013; Strelakova 2015). But as Lawlor and Tolley (2017) suggest, media can both signify narratives for the public and also be influenced by them. So, in line with these and other scholars (e.g., Kennedy, 2010), we argue that while scientific work can impact media, the ways scientific initiatives are situated in the media impacts how people may view scientists, the investments made to engage in certain avenues of inquiry, or the scientific work itself.

Located in Arizona, United States, B2 conducted innovative scientific experiments in the early 1990s that sealed people inside interconnected glass domes called ‘biodomes’ in order to explore technologies that support human sustainability on other planets. The role of B2 for scientific knowledge production has shifted over time, and currently B2 functions as a research facility owned by the University of Arizona. This scientific center has become “a Miniature Earth under a Dome”<sup>1</sup> used for research purposes while also functioning as a site for educational outreach, while keeping the memory of its past space experiments alive through museum activities and displays. Research happening at B2 today tends to explore topics related to climate change, preservation, ecology, and human health. But, for its “quarter century birthday,” Huff Post’s paradoxical title conveys the current lack of notoriety of this historical research site still connected to its past: “The World's Largest Earth Science Laboratory You've Probably Never Heard Of,” (Sherriff L., 19/05/2016, Huff Post). B2 as a research and educational site is therefore an interesting case to explore for this study given the public interest in early years, the scholarly import of the location today, and how related scientific activities and events have been presented by the media.

To interrogate media coverage of B2 over time and the implied activities of B2 in the region across historical eras, this article is organized in the following ways. First, we review literature on media coverage of scientific projects. Second, we present the socio-cultural framework used for analyzing media coverage of the Biosphere 2, and we set up our research questions. Third, we discuss our quantitative methodological design, one favoring an interpretive logical approach, one that also mirrors other ‘case study’ type research studies. Fourth, we offer a clustering analysis of news articles in order to provide rich detail of media storytelling about B2. Finally, we pull the various analytic discussions together, and we situate our findings in relation to ongoing conversations about science in the media and information diffusion.

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<sup>1</sup> For a current scientific presentation of Biosphere 2: Culot A., "In Arizona, a Miniature Earth under a Dome", 12.21.2018, CNRS News, online: <https://news.cnrs.fr/articles/in-arizona-a-miniature-earth-under-a-dome>

## Literature on Media Coverage of Scientific Projects

### *Newspapers and Innovative Scientific Projects*

Newspaper coverage of scientific issues, or news diffusion as is the aim for this research, impacts the way readers perceive and act upon scientific findings. For example, Quesnel and Ajami (2017) point to shifting water-consumption patterns given climate reporting, and Chen, Huang, and Li (2020) examine news coverage of the COVID-19 pandemic and its potential impact on tourism. Feldman, Maibach, Roser-Renouf, and Leiserowitz (2012) examined climate change coverage across news television channels, and Haider-Markel, Allen, and Johansen (2006) explored variations in news coverage of a court decision related to a Texas antisodomy law in the United States. Holliman, Donovan, Scanlon, Yates and MacQueen (2001) explored media coverage of the Human Genome Project, pointing to an ongoing “tension between scientific investigations and media representations, which inform current debates about the relationship between science and society” (p. 2). Indeed, the ways that scientific projects get reported across outlets have been the focus of scholarly inquiry given the influence reporting trends have on public perception, opinion, and behavior. This study of B2 news coverage is similar to these kinds of projects that have examined news patterns tied to particular events in order to uncover they myriad ways media framing can impact reader perceptions.

Although scientific reporting is influential for people, Kennedy (2010) points to the decline over the years in the space devoted to scientific articles in the American press, and Miller (1983; 1998; 2004) points to the importance of readers’ scientific literacy. Russell (2010) suggests that there exists, “a greater need than ever before for journalists who are skilled in reporting both the underlying complexity of science and technology as well as the legal, ethical, and political ramifications [of scientific work]” (p. 13). News coverage examined for this study thus took place at a time when trends in science reporting were shifting more generally.

Of course during the construction of B2 (1987-1991) and its two missions (1991-1994, cf. Table 1) the Internet was in its infancy<sup>2</sup> and the press was only accessible in its printed version. Online social networks did not flourish until the 2000s (Balbi and Magaouda, 2018). While both old and new media have contributed to public science literacy (Miller and Kimmel, 2001; Miller 2010) and have had influence on public debates in science (Scheufele, 1999), “Social media ... appear to play a modest role in informing Americans about science” (Pew Research Center, 2017). So, while multiple platforms now exist for scientific news sharing, studying how US newspapers have covered the main scientific, legal and economic events that have punctuated the history of scientific center B2 can uncover some of the ways press coverage may have impacted public understanding of a scientific research site and its related enterprises.

### **Analytic Approach for Exploring Trends and Patterns in News Coverage**

A wide variety of studies explore discourse in differing ways, and many of those explore large bodies of text with a focus on language in use given particular contexts, as well as ideologies represented in communication. Augoustinos and Crabb (2010) used this approach to explore texts referring to the debate on genetically modified foods in the UK. Their research

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<sup>2</sup> The World Wide Web was created in 1990 and the first browser (Ncsa Mosaic) in 1993.

demonstrates how the debate on GMOs has been presented in the media as a ‘battleground’ of competing interests. Studies like these tend to focus on discursive patterns in institutionalized talk, in the media, or in ‘everyday’ settings as they impact policy decisions across groups and societies.

Research on media representation of controversies in science has increased considerably in recent years. However, many of these studies are driven by a ‘framing’ analytical focus, making it possible to determine the presence and frequency of predefined thematic categories called frames (Priest and Ten Eyck, 2003; Nisbet and Huges, 2006; Gaddekar, Krishnatray, and Ang, 2014; Strelakova 2015; Speakman, 2021). This type of approach faces several limitations, including the difficulty of scaling up and analyzing large sets of data comprehensively. Indeed, the coding of a small selection of data by at least two hand encoders is a very time-consuming task. In order to manage this challenge, Lawlor and Tolley (2017) analyzed 4,000 articles from four Canadian newspapers in order to compare the media’s framing of immigrants and refugees, and they proposed a two-step process. First, they built a dictionary of cue phrases with the WordStat software, then they used the Lexicoder software to carry out a content analysis. They discussed the issue of breaking a text as a bag of words (Salton and Lesk, 1968) and its consequences for interpreting the meaning of a full sentence but they argue, quoting Grimmer and Stewart (2013), that the limitations of an automated approach can be overcome by a thorough analysis of the results.

We adopt a similar approach, that is to say we do not a priori categorize the articles as is typical when researchers work from a ‘frame theory’ perspective. This ground-up approach to a large data set allows for insights that would not be possible with predefined categories. Our work focuses on lexical and cluster analysis as a way to understand the circulation of news and explores discursive trends in order to learn more about how a site of scientific experimentation functions in a community, a region, and beyond.

## **A Socio-Cultural Framework**

As a research and education site for the study of ecosystems and their interactions with climate change, B2's scientific work tackles environmental issues and related public concerns. Environmentalism gained public interest and support in the 1970s and 1980s in the United States, also in the 1970s Earth Day became an annual worldwide event in support of environmental protections (Gottlieb, 1995). B2 thus came about at a time when environmental issues were becoming socially, culturally, and politically salient in public consciousness.

Conceptually, this study is driven, in part, by notions of the agenda-setting function of media (McCombs & al. 1972; Soroka, 2002; McCombs 2004; Iyengar 2015), that the media impacts the broader societal focus on certain topics. “...the media, in their broad and diverse totality, provide an important cultural context from which various publics draw both vocabularies and frames of understanding for making sense of the environment generally, and of claims about environmental problems more specifically” (Hansen, 2009, p. 6). Soroka’s (2002) work also exemplifies the kind of research that points directly to the relationships between media coverage, public concern, and societal agenda. Moreover, Hilgartner and Bosk (1988) point to a kind of ‘public arena’ wherein journalists compete with other stakeholders in ways that impact community views and the societal agenda.

This research is in line with Hansen's (1991) suggestion, that "if we wish to understand the role of the mass media in the development and the elaboration of environmental issues, we must turn to a constructivist framework..." (444). Within Hansen's (1991) call for constructivist approaches to the study of news coverage, he suggests that "it is to the wider notion of cultural resonances that we must turn in order to account for the very different careers of various environmental problems" (p. 451). Hansen (2018) focuses extensively on the role of communication and the social construction of environmental events, arguing, "The constructionist perspective provides a framework for analyzing and understanding why some environmental issues come to be recognized as issues for public and political concern, while others – potentially equally important issues – never make it into the public eye, and thus fail to command the political attention and resources required for their resolution (p. 34).

### **The Current Study of Biosphere 2 News Coverage**

We engage in this work in order to glean how the media situated B2 over time. We also aim to provide a broad historic sense of a case of a scientific experiment that became part media intrigue across historic eras and media types. To the best of our knowledge, no analysis of the media coverage of B2 in United States press outlets from the date of its creation to the present day has been carried out.

B2 is located at the base of the Santa Catalina Mountains just north of Tucson, Arizona, about 50 kilometers from the city. Originally funded by businessman Ed Bass, B2 was built between 1987 and 1991 under the supervision of Space Biospheres Ventures (SBV), a joint venture with Margaret Augustine as CEO and J.P. Allen as Director of Research and Development (Allen, 1990). B2's initial goal was to determine whether a closed ecological system inhabited by humans could be maintained in equilibrium for long time periods. As described by a crew member, "*Biosphere 2 is a 3.15-acre space containing an ecosystem that is energetically open (sunlight, electric power, and heat) but materially closed, with air, water, and organic material being recycled*" (Walford, Harris, and Gunion, 1992). It aimed to demonstrate the feasibility of establishing biospheres, or space colonies, on planets in the solar system: "*SBV began the Biosphere 2 project with the idea that it would be directly sunlight-driven, modeled such that we would get valuable ecological knowledge for the Earth as well as developing further our conception of a well-developed Mars habitation base,*" (Allen, 1990). In fact, the B2 project combined three objectives when it was launched (Nelson, 2018). The first objective was to verify the scientific feasibility of a closed ecological system inhabited by humans. The second objective, positioning B2 at the edge between amusement parks and science centers, was to attract visitors, as guided tours were quickly organized on the site. The third was to develop eco-technology products. The last two objectives aimed to make the project economically viable.

After various scientific and management problems were widely publicized in the press and in books (e.g., Poynter, 2006), the management of B2 was commissioned to Columbia University then later, to the University of Arizona. Consequently, the nature and missions of the institution were profoundly redefined. Since 2007, B2 has combined two types of missions. The scientific mission is one carried out by the University of Arizona focused on the study of ecosystems and the impact of human action on the biosphere. The educational and mediation mission exists in the form of a museum and different types of media to disseminate information. A hybrid economic model is based on public and private resources; it also makes use of mass tourism and

event communication, as the institution is subject to constraints in terms of attendance and the funding of its activities. The University of Arizona has undertaken a reflection on the visibility and economic viability of the site, the policy of scientific mediation, and on forms of medialization that integrate digital communication technologies (Stokstad, 2012; Estrada and Bonine, 2017). Moreover, the institutional identity and the development strategy remain divided between the heritage enhancement of the initial project (to create a prototype of lunar colonization) and the scientific reorientation on the observation of ecosystems.

Our analysis of the present media coverage of B2 reveals that its history has forged its institutional identity, and that the media coverage of B2 combines the reference to the past space experiment and the present research programs. Research conducted by the University of Arizona addresses big challenges for the understanding of evolving ecosystems in the complex interdependencies of atmosphere, soil, water, flora, and fauna (Stokstad, 2012). However, it seems that the ‘space history’ is still present in current-day publications because that particular project remains part of the identity of this place. That is, there are frequent references to the space ranch experiment in press articles, and also references to ‘biospherians’ in interviews and books, even though the site is home to world-class science experiments today.

In this study, newspapers are considered a primary media type that influences how B2 is known and positioned, and this motivates our focus on the role played by the press in situating scientific experiments conducted at B2 for the public. The distinctive choice to explore the regional, metropole, or elite press outlets allows us to examine if the representations of this research center and its activities, implied values, or amount of information differ across sources (i.e., regional, metropole, or elite) or media scale (i.e., local, regional, national outlets). We explore a correlation between the profile of stakeholders mentioned or quoted in articles and the choice of information diffused to report on the research center and its experiments. Findings emerging from this study can inform understandings of media behavior around other scientific experiments that get taken-up in public consciousness. With these intentions in mind, we addressed the following research questions in this study:

**Research Question 1:** What positions were discursively set in the U.S. newspapers regarding the B2 through time, and do those positions differ across elite, metropole, and regional press?

**Research Question 2:** What kinds of information and representations concerning the research center and the scientific research on ecosystems conducted at B2 were diffused over time and what is the nature of the talk associated with those representations in the press?

**Research Question 3:** Who are the main stakeholders situated in the press as legitimate spokespeople or representatives of B2?

## Method and Data

### *A Quantitative Case-study Design*

In order to uncover patterns in media coverage over time we used a quantitative natural language processing approach. In doing so we relied on content analysis and a cluster method. In other words, the analysis focused on words and most mentioned people or organizations significantly highlighted in the articles, as well as main meaning universes.

B2 functions as a kind of ‘case’ of scientific experiment, one that caught international attention and likely influenced readers of all kinds to pay attention to scientific questions. By deploying an “analysis of a case” (Creswell, 2007, p. 78), we were able to focus on findings that can be translated to other similar cases. Findings can also inform the way we understand similar scientific experiments that get taken up and situated in the media.

We approached the B2 case interpretively, taking an inductive approach drawing themes and findings directly from the data themselves. In line with Lindlof (1995), we approach this research recognizing new conceptualizations and understandings will come from the data rather than approaching the work with notions or hypotheses predicting what we might find. While we analyzed media stories with clear foci in mind, our findings emerged from the data, from the ‘ground’ up.

### *Data Collection*

First, articles were collected from the Factiva database which indexes the main US newspapers. Indeed, the top 25 ranked newspapers, according to Alliance for Audited Media, are indexed by Factiva as well as the regional newspapers of Arizona. The collecting was carried out with a query using two keywords ‘Biosphere 2’ or ‘Biosphere II’ for the period of time between July 1 1984 until April 15 2019, for articles written in English and published by US newspapers. This query harvested 425 articles.

We then carried out a step of curation in order to eliminate articles by applying some rules. The first rule was to remove duplicates. Second, articles that mentioned Biosphere 2 or Biosphere II in an incidental way such as “this place near Biosphere 2 was sold” or “from the mix-tape era - such as Biosphere 2, the Y2K Bug and Hillary Clinton's hairstyles” and so on, were double checked by two authors. If the two opinions were identical, (eliminate or retain), an agreed-upon decision was made. If the two opinions were different, the article was retained. Finally, after applying these rules, 405 articles were kept for inclusion in the corpus.

Collected articles were extracted using Factiva’s RTF format curated and indexed with metadata such as id (a unique identifier), date, author, source, media type, number of words. Following the classification proposed by others (e.g., Strekalova 2015, Ten Eyck & Williment 2003), we distinguished three kinds of media: elite, metropole and regional. In our corpus, there are 4 elite newspapers, *The New York Times*, *The Wall Street Journal*, *The Washington Post*, *The Financial Times*; 6 metropole ones, *Arizona Republic*, *The Boston Globe*, *Chicago Tribune*, *The Las Vegas Review-Journal*, *Los Angeles Times*, *USA Today*; and 14 regional ones, *Arizona Daily Wildcat*, *Atlanta Journal and Constitution*, *Austin American-Statesman*, *Buffalo News*, *Colorado Springs Gazette Telegraph*, *Los Angeles Daily News*, *St. Louis Post-Dispatch*, *St. Petersburg Times*, *Seattle Times*, *The Arizona Daily Star*, *The Cincinnati Post*, *The Hamilton Spectator*, *The*



*Pantagraph Bloomington, The Salt Lake Tribune*. Metadata were recorded in a specific file used to automatically build a corpus in compliance with the XML-TEI standard.

### *Data Analysis*

To identify main lexical classes, we performed the algorithm proposed by Reinert (1983). This algorithm relies on descending hierarchical classification and factorial analysis. We briefly summarize this algorithm, though more details can be found in the writings of a variety of scholars (e.g., Reinert 1983, 2007; Ratinaud and Marchand, 2015; Ramos, Rosario Lima, and Amaral-Rosa, 2019). The particularities of this algorithm are as follows. A corpora is a collection of text units (named TU), in our corpus TU are media articles, and each TU is divided in contextual units (named CU), which are usually of fixed length (around 40 words), but taking into account punctuations. In each CU, only verbs, nouns, adverbs and adjectives are kept and lemmatized. A specific top-down hierarchical classification is then carried out; this classification technique is surely the most original feature of Reinert's algorithm. It is based on a series of bi-partitions built on the basis of a correspondence factor analysis (CFA) conducted on a binary table T (absence/presence) that cross-references selected TU with selected CU. In this perspective, the number of final classes is not a priori given. In order to give a profile at each class, and to determine the 'weights' of each word of these classes, a chi-square is computed to evaluate the degree of connection between each word and each class. All classes gather contextual units (CU), not text units (TU). Consequently, this algorithm exhibits topics, main lexical classes in texts, and it does not categorize texts. This algorithm is implemented with free open access Iramuteq<sup>3</sup> which offers several heuristic visual representations in order to help the interpretation of the classification. For this study, two visual representations were used. The first one, named dendrogram, shows the computed tree of classes with their percentage. At each class is an associated a list of representative words or metadata with their chi2-square and the p-value. Metadata are important because they provide a way to access articles (with their date, source, etc.) for qualitative analysis. Indeed, it is possible to interpret the lexical universe of each class. The second visual representation is a projection of the main words of each class on the factorial design, allowing for the evaluation of the proximity to or the opposition between classes as shown in Figure 4.

To identify stakeholders mentioned in articles we relied on the Stanford Entity Recognition<sup>4</sup> software which relies on machine learning techniques. We cross checked its outputs using the text mining platform TXM<sup>5</sup> which offers useful corpus query language CQL<sup>6</sup> associated with concordances techniques. In order to compare the media coverage of stakeholders, we defined media coverage score (SC) as follows: SC is equal at  $N/N_{all}$  where N is the number of different articles in which the stakeholders is mentioned and  $N_{all}$  is the total number of articles published in the chosen era. This score favors stakeholders who are mentioned in different articles and not stakeholders mentioned many times in the same article.

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<sup>3</sup> <http://iramuteq.org/>

<sup>4</sup> <https://nlp.stanford.edu/software/CRF-NER.html>

<sup>5</sup> <http://textometrie.ens-lyon.fr/>

<sup>6</sup> <https://www.sketchengine.eu/documentation/corpus-querying/>

## B2 Analyzed across Eras

In order to compare the flows of media coverage, we divided the study period into 9 eras based on key events (Kepplinger and Habermeier, 1995; Zerback, Reinemann, Van Aelst, and Masini, 2020). In our study, we determine two categories of ‘key events’ that have guided the delimitation of these areas through time. Management events include financial and administrative decision-making criteria, the most mediatized scientific events announced by the scientific board. We used the name ‘Interphase Era’ for the three time periods of management vacancy. The breakdown of articles is shown in Table 1.

**Table 1. Breakdown of articles by period of time**

Time period	Era name	Total of articles
1 July, 1984 – 30 June, 1987	Space Biospheres Era	1
1 July, 1987- 25 September, 1991	Construction of Biosphere Era	35
26 September, 1991 –26 September, 1993	First Mission Era	147
27 September, 1993 - 5 March, 1994	Interphase 1 Era	47
6 March, 1994 – 6 September, 1994	Second Mission Era	83
7 September , 1994 – 1 January , 1996	Interphase 2 Era	5
2 January , 1996– 9 January, 2003	Columbia Era	21
10 January , 2003 - 4 June, 2007	Interphase 3 Era	26
5 June, 2007 –15 April, 2019	University of Arizona Era	44

## Results

The first research question asked about the positions that were discursively set in the media regarding the B2 history through time, and whether those positions differ across elite, metropole, and regional media. To begin to address that question, the main characteristics of the flows of articles published during the 9 eras are shown in three figures. Figure 1 shows the flow for the three categories of newspapers, figure 2 shows, for each source which published at least two articles, the number of articles published during each era, and figure 3 displays a bar graph showing the volume of articles published by each source grouped by category for all eras.

Several of characteristics deserve to be highlighted. First, media coverage by elite and metropole newspapers was concentrated on the first and second mission era (fig. 1). Second, only four newspapers, one elite, one metropole and two regionals, published more than 20 articles (5%) during all eras: *The Arizona Daily Star* (N=172), *The New York Times* (N=43), *The Boston Globe* (N=25) and *The Salt Lake Tribune* (N=21). Third, with the exception of *The Arizona Daily Star*, all newspaper flows follow a downward trend after the second mission era (fig. 2). A more thorough analysis of flows (fig. 2) shows that the *New York Times* and *Arizona Daily Star* have practically homothetic flows with the total flow during the first and second mission era because they were the newspapers that published the largest number of articles and were thus most influential on these findings.

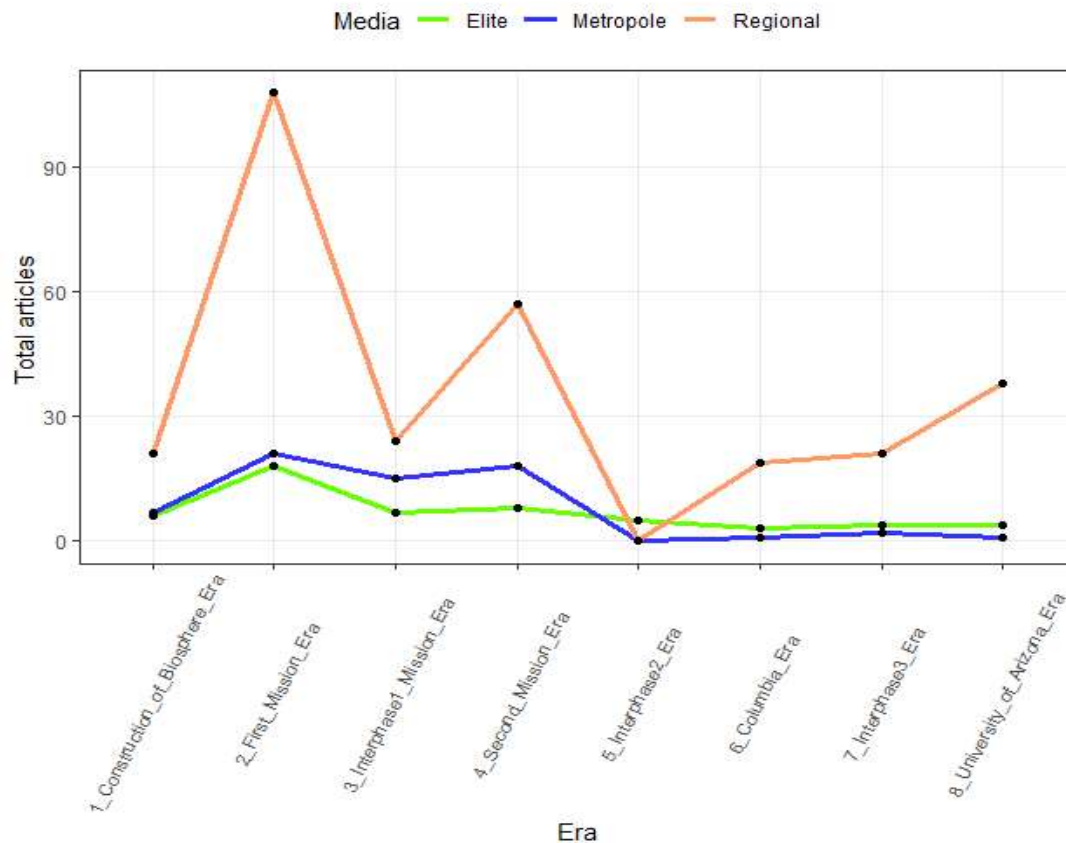


Figure 1. Flows of all articles for each category of newspapers.

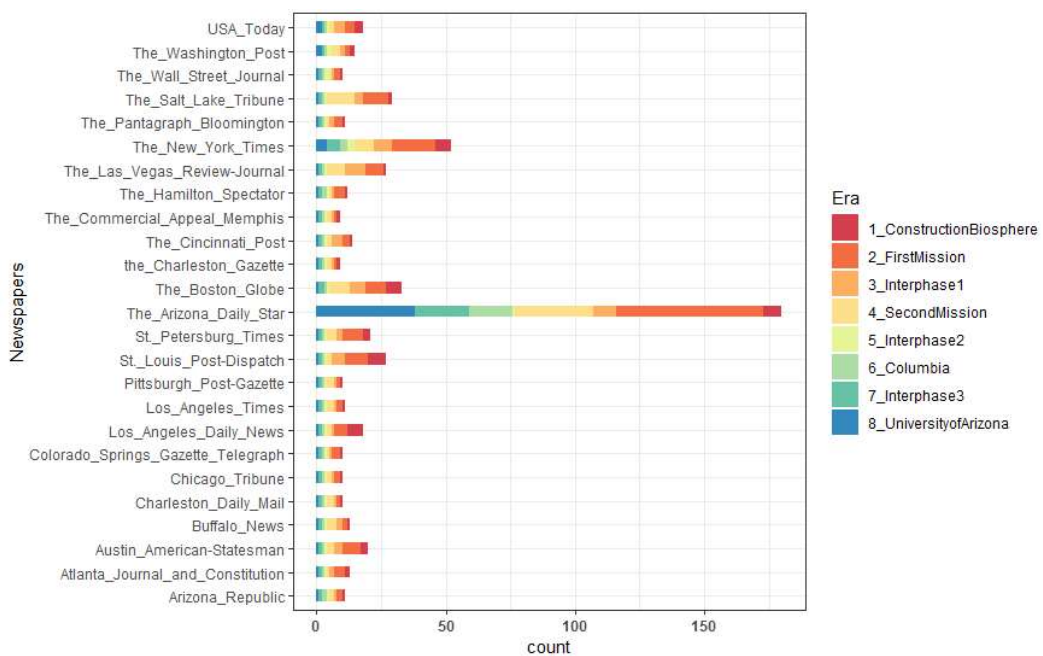
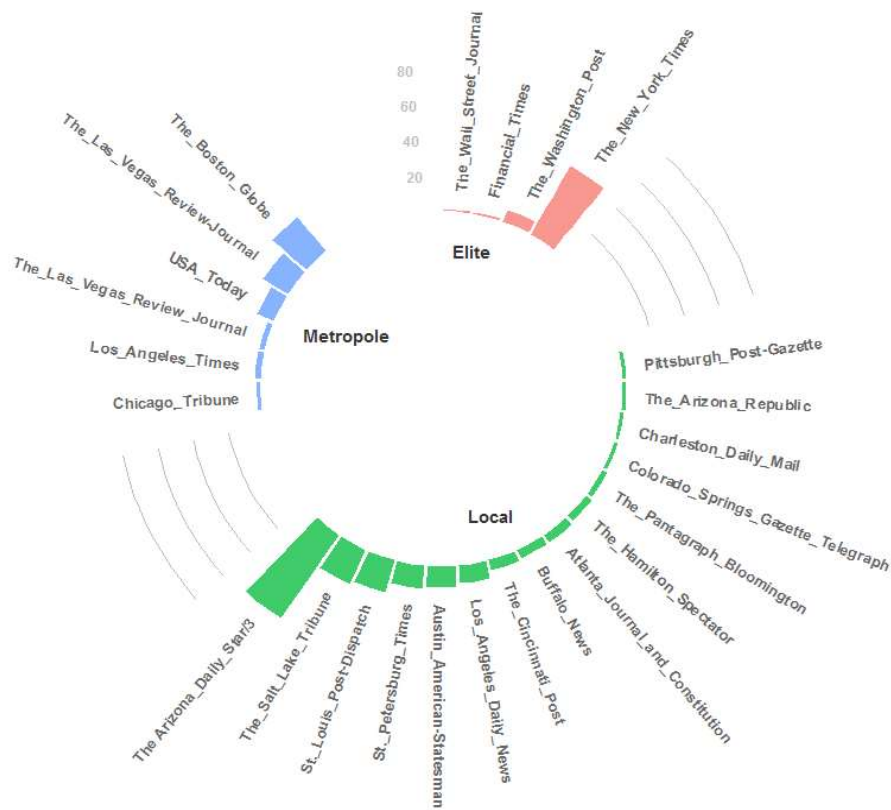


Figure 2. Total of articles by newspapers which published at least two articles



**Figure 3.** Total of articles by group of newspapers (Arizona Daily Star's flow is divided by 3 in order to get a balanced graph)

To extend beyond the flow analysis, a log likelihood (LL) score was used to measure the difference between frequencies of words or lemma. The main advantage of LL is that it enables the ability to make comparisons across differently-sized corpora (Rayson & Garside, 2000). It is worth recalling that a LL score greater than 3.84 or less than  $-3.84$  are significant because they produce a p-value of less than .05 (Rayson and Garside, 2000; Poole, 2016). Focusing our study on the First and Second mission era, we carried out a comparison between elite, metropole and regional corpus, looking for lemma or entity names which have a significant LL score (positive or negative), the results are shown in Table 2.

It appears that the regional newspapers focused on the business aspect of the project, using frequently a word like *company* and referring several times to the stakeholder, Space Biospheres Adventures (SBV), which was in charge of the B2 management. They also insisted on a sensational event, the trial between Louis Hawthorne and SBV. This result is in agreement with the theoretical framework which considers that local/regional media focus on "local rather global problems" and are attentive to the regional business issues (Hansen 2018 p.95).

**Table 2.** Words with significant LL score

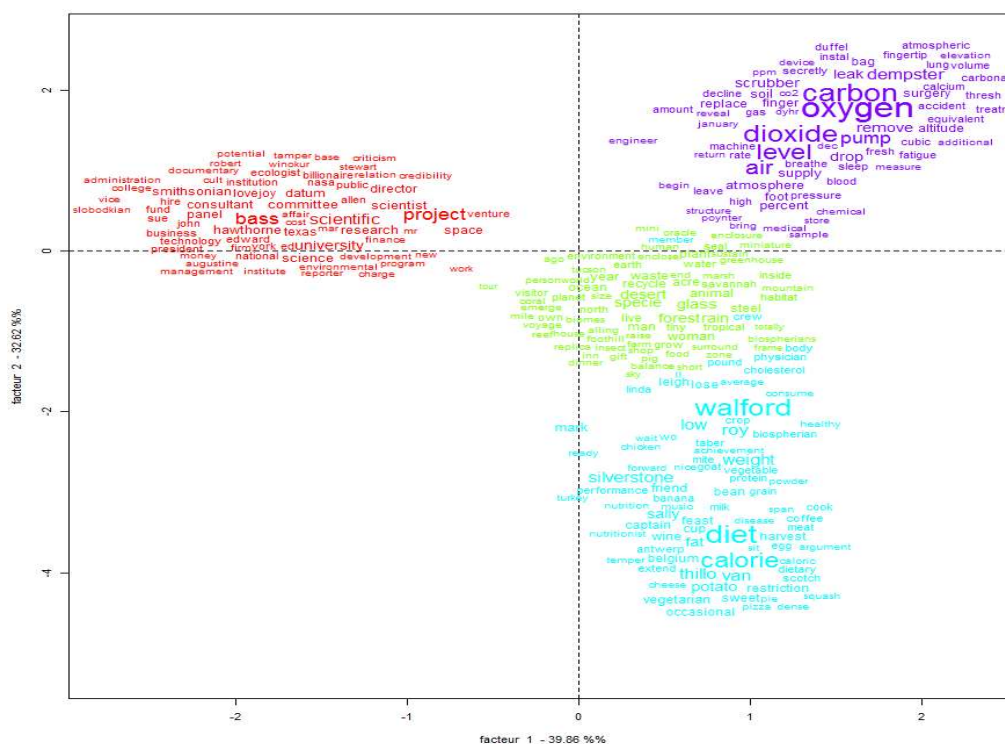
Era	Elite	Metropole	Regional
First Mission	Synergia Ranch (+6.2)	Lesson (+7.2)	Company (+7.7)
	Leader (+5.8) Dome(+5)	Unique (+6.6) Environment (+6.1) Scientist (+4.4) Biospherian (+3.9)	Space Biospheres Adventures (+6.3) Hawthorne (+4)
	Company (-4.2) Walford (-4.0)	Hawthorne (-4.7)	Chemical (-5.5) Experiment (-5.0) Synergia Ranch (-4.9)
Second Mission	Dome (+6.4) Scientific (+5.4)	Leigh (+5.6) Airlock (+5.0) Walford (+4.7) Crewmembers (+4.7)	Space Biospheres Adventures (+4.2) Alvarez Romo (+4.2)
	Augustine (-5.3) Space Biospheres Adventures (-4.7)		Walford (-4.4) Airlock (-4.0) Leigh (-4.0)

In the first mission era, metropole newspapers emphasized the scientific issue using words like *lesson*, *unique*, *environment*, and *scientist*. In the second mission era, they highlighted management troubles. The editorial position of elite newspapers appeared to differ from that of regional and metropole newspapers. They focused on the innovative building itself, particularly by giving descriptions of the ‘dome,’ its organization and its scientific equipment.

The list of words with significant LL score shows the intermingling of the main referential universes and the most mentioned people and organizations. We reveal different universes of meaning by distinguishing, on the one hand, the lexicon describing the scientific project and the experiments carried out in the domes, and, on the other hand, the lexicon describing disrupting events. Those events are related with the mentioned stakeholders, most often the crew members involved in the scientific experiments, those who have been the subjects of direct or reported speeches.

Lexical classes emerge from the statistical processing of articles applying the algorithm proposed by Reinert (1983). They result from the iterative clustering of words forming the immediate linguistic environment, the contextual unit (see *supra*). Interpreting this cartographic representation implies returning to texts that contain lexical forms in order to put them in their communicative frameworks.

Depending on the eras, 3 or 4 classes per era have been identified. Main meaning universes and most mentioned people or organizations are shown in Table 3. Within the different eras and the computed classes, two main categories of most mentioned stakeholders can be distinguished, as shown in Figure 5.



**Figure 4.** Example of a projection of the main words of each class on the factorial design (First Mission Era)

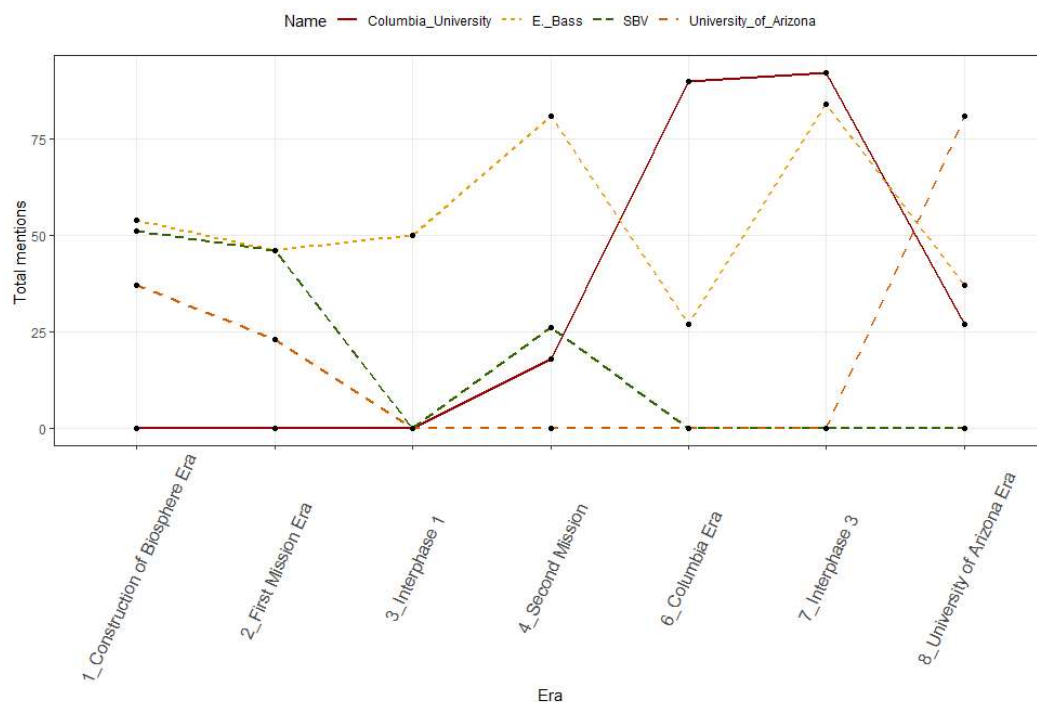
**Table 3.** Main meaning universes and most mentioned people

Era	Number of classes	Classes	Most mentioned people or organizations in each era (Score coverage)
First Mission	4	<p>Class 1 (33.8 %): Relationships between Biosphere2 management and scientific community.</p> <p>Class 2 (29.8 %): Biosphere 2 device and its inhabitants</p> <p>Class 3 (11.1 %): The diet imposed on the crew members by Dr. Walford</p> <p>Class 4 (25.3 %): The decline of oxygen in Biosphere 2 and the measures taken by management to tackle with this issue.</p>	<p>Edward Bass(0.46)</p> <p>Space Biospheres Ventures(0.46)</p> <p>Roy Walford(0.34)</p> <p>Jane Poynter(0.32)</p> <p>University of Arizona(0.23)</p>
Interphase 1	3	<p>Class 1 (43,32 %): The exit of the Biosphere 2 team and problems they encountered</p> <p>Class 2 (41.58%) : The new scientific project of Biosphere 2</p>	<p>Edward Bass(0.50)</p> <p>Abigail Alling(0.48)</p>

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		Class 3 (15.1 %): Composition of the crew's diet and its consequences	Linda Leigh(0.39) Mark Nelson(0.36) Sally Silverstone(0.26)
Second Mission	3	Class 1 (44.52 %) Edward Bass' decision to dismiss the members of the committee in charge of the Biosphere 2 project. Class 2 (12.31%): Columbia University and Harvard taking charge of the scientific management of Biosphere 2 Class 3 (43.17 %): The new crew organization for the second mission	Edward Bass(0.81) Margret Augustine(0.65) Mark Van Thillo(0.39) Abigail Alling(0.38) Chris Helms(0.38) Martin C. Bowen(0.22)
Columbia	4	Class 1 (30.38%) : Biosphere 2 as a place of visit and education Class 2 (23.21 %) : The Columbia's scientific project for Biosphere2 Class 3 (13.5 %) : New installations for students at Biosphere 2 Class 4 (32.91 %) : Experiments in the ecosystem at Biosphere 2	Columbia University(0.90) John Adams(0.31) Edward Bass(0.27) Barry Osmond(0.22) Chris Bannon(0.22)
University of Arizona	4	Class 1 (32.41 %): The environmental scientific program at Biosphere 2 Class 2 (19.46 %) : Relationships between Edward Bass and the new project for Biosphere 2 Class 3 (18.45 %): Biosphere 2 as touristic place Class 4 (29.61 %): Studies from University of Arizona in the area of hydrology at Biosphere 2	University of Arizona(0.81) Edward Bass(0.37) Columbia University(0.27) Joaquin Ruiz(0.25)

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**Figure 5.** The four most mentioned people and organizations through all main eras

In each era, the computing of classes brought out groups of words. Across eras, groups converged on media discourses that describe the project of B2 in relation to the scientific leadership that evolves over time, due to the complicated relationships between B2 management and the scientific community. Groups of words describing scientific experiments and methods, which were the subject of controversy and sometimes conflicting events, were present from the beginning of the project to the end of the second mission. The main commented events (listed in Table 4) were identified by analyzing article flows, based on the observation that a peak in flows corresponds to an event that the media report on (Tannier and Vernier, 2016). The controversial period of B2 appears to be clearly situated between 1 July 1984 and 6 September 1994, during the First Mission and the Second Mission eras. A major difference in the media coverage of events between elite and metropole newspapers and those in the regional category was the importance given to sensational events by regional newspapers.

**Table 4.** Main commented events in each era

Era name	Main events <sup>7</sup>
First Mission Era	Outside air is pumped into Biosphere 2 After two years eight to leave isolation of Biosphere 2
Interphase 1 Era	A New Crew and New Rules for Biosphere Too Rich a Soil: Scientists Find the Flaw That Undid the Biosphere
Second Mission Era	7 locked up in 3-acre Biosphere 2

<sup>7</sup> The headlines of newspapers were used to describe the main commented events.



Texas billionaire boots managers of Biosphere 2  
Main financier of Biosphere takes control

Columbia Era

Australian new president of Biosphere 2 Plant biologist is expected to strengthen credibility of 'space station on Earth Graduate program will leave Biosphere 2

University of Arizona Era

U. Arizona Biosphere 2 brings science to the people  
World's largest earth-science experiment: How water moves through landscapes

Our results reveal prevalent topics that dominated the U.S. newspaper coverage concerning B2 management, research programs, and other activities in relation to changes in prominent stakeholders representing B2; we also identified the four most mentioned stakeholders. The results obtained for the first and second mission eras confirm one of the assumptions of the agenda setting theory, which is one of the components of our theoretical framework. Indeed, this framework considers that Elite newspapers "shape the agendas of other newspapers" (Pfau et al. 2004, p. 80). The results for these two eras show that the topics and the stakeholders belong as much to the business field as to the academic one (two stakeholders come from the business field and two others from the academic one). This can be explained by the economic policy of the original project conceived by the businessman Ed Bass. For its economic profitability, Ed Bass positioned B2 as both an amusement park with spin-off products and a science center. As a result, the press has attributed a dual identity, both economic and scientific, to this institution, which, in addition to the difficulties encountered during its experiments, has been detrimental to its reputation as a research center. In this respect, our results also bring to light the societal goals associated with this scientific project and highlights the opposition between two conceptions of scientific understanding.

However, media coverage changed during the experimental phases carried out between 1991 and 1993, when insurmountable difficulties associated with scientific frauds appeared concerning the oxygen deficit and the feasibility of closed ecosystems allowing the production of food resources, alongside the problems of human cohabitation in confined environments. We show that elite and metropole newspapers were the first to cover the B2 project but, as soon as certain events casted doubt on the scientific basis of the project after the second mission, these two categories of newspapers significantly reduced their coverage. The scientific re-orientation from off-planet colonization towards contemporary research on crucial environmental issues on Earth during The University of Columbia and the University of Arizona (UA) eras has not caught the attention of elite and metropole newspapers. Indeed, those newspapers have not reported on B2 shifts in foci to environmental issues on Earth. Similarly, although the educational and mediation mission clearly have appeared from the Columbia era and have been developed during the UA era, elite and metropole newspapers have not provided critical information on Earth systems science research conducted at B2 for the general public.

In contrast, regional newspapers intensified their media coverage on all aspects related to B2, like its management, financing, research projects, educational outreach, leisure and other related opportunities. In the most recent era, from 2007 to present day, it appears that the presence of the UA has become prominent during the time period that it took over the management of the B2. The results concerning those changes in media coverage mitigates the assumption of the above-mentioned agenda setting theory. Two factors can explain this observed divergence. First, the UA research recognition, the university being ranked 1st in the US for environmental research and 1st in the Shanghai ranking for research on water resources, which positions it as a reference center on environmental subjects. In addition, a socio-economic factor plays an important role; UA is the largest employer in Pima County, a major socio-economic player in the region and therefore a major stakeholder in the region.

### **Discussion and Study Limitations**

Reconstructing how a number of elite, metropole and regional U.S. portrayed B2 over time and covered its innovative activities, shows their evolving meaning-making of B2 through ideologies and scientific knowledge. In the socio-cultural framework guiding this work, we took into consideration the “wider notion of cultural resonances” proposed by (Hansen, 2018); he described it as “the ‘cultural givens’ of society” (p. 451) that play a role in the identification of topics covered by the media. Among these ‘cultural givens’, researchers point out the ‘mastery over nature’, the predominance of ‘science discourse’ and scientists, the ‘progress through science and technology’ or other ideologies or representations anchored in historical periods of time (Hansen, 1991, p. 451-452). In this direction, following the historical and scientific event of the first moon landing on July 20, 1969, the socio-cultural context, in the 1970s and 1980s, was driven by the possibility of sending space shuttles for the development of space colonies, with the hopes of being able to transform planets into new habitable lands for humanity. The American physicist Gerard O'Neill’s utopian project, in his famous article "The colonization of space," published in 1974, was based on immense space stations in the shape of cylinders containing settlers' dwellings and fields, forests. Therefore the innovative scientific project of the beginnings of Biosphere 2 initiated by Texas oil billionaire Edward P. Bass in the late 1980s, in which he was studying the feasibility of colonization outside planet earth for future long-term space stays, was totally in line with the space ideology of that period of time and with its representations of settlers conquering new space territories. This can thus explain why the elite and the regional press followed with such great interest and considered seriously a scientific research on the feasibility of reproducing on a reduced scale, in the middle of the Arizona desert, the terrestrial geobiological system in closed ecosystems.

From a “constructionist perspective on social problems” (Hansen, 2018, p. 34) as a framework for analysis, we also highlighted the rising public interest in environmentalism during the 1970s and 1980s (Gottlieb, 1995), and the role played by the media as a cultural context for

understanding the societal importance of environmental issues. In line with growing public concerns, sustainability on Earth rather than a still hypothetical “elsewhere” has raised urgent issues to consider. The societal importance of environmental issues resonates with the University of Arizona's scientific reputation for environmental studies. In recent years, B2 external communications have insisted on the need to study “the complex interdependencies of atmosphere, soil, water, flora, and fauna” (B2 leaflet “Grand challenges. Global solutions. Biosphere 2”) and “to address fundamental grand challenges in Earth systems science” and “future climate scenarios” (B2 leaflet “Landscape Evolution Observatory”). The regional coverage, largely provided by The Arizona Daily Star, of B2 as an important site for scientific exploration is part of the mission fulfilled by local press (Adkins-Covert, Ferguson, Philips, and Washburn, 2005; Kaniss, 1991). The preeminence of this local coverage can be explained by the high socio-economic stakes involved. In this region where nature is valued, the cultural attachment of the local population to the semi-desert landscape, combined with serious water issues, as well as a tradition of extractive industry activities, bring about growing controversies for the public. Alongside the interest to study biospherics and closed ecological systems (Allen, Nelson, and Alling, 2003), the impact of Biosphere Reserves on regional sustainability (Borsdorf, Pelenc, Reutz-Hornsteiner, Le Tourneau, and Coy, 2014) and problems of governance (Brondizio and Le Tourneau, 2016) have become crucial. Questions of human survival on Earth remain urgent today because, as Bruno Latour put it: where are we going to land? (Latour, 2018). Future media research can continue to examine how science storytelling happens, changes over time, and impacts public perspectives on cases of experimentation specifically, or on science more generally. Certainly our work is not the first to examine how scientific news gets diffused over time. Maillé and Saint-Charles (2014), for example, explored social networks to gain insights about a developer's information-diffusion strategies in Canada. More similar to our work, Feldpausch-Parker, Ragland, Melnick, Chaudhry, Hall, Peterson, Stephens and Wilson (2013) examined news coverage in the United States on carbon capture and storage across four states over time. We thus contribute to an ongoing conversation about science information diffusion, and scholars can utilize our findings to spur additional analyses of scientific work that becomes sensationalized, politicized, and consumed in variegated ways by non-expert publics. Media practitioners can consider trends in storytelling about a case of scientific experimentation over time to inform their work, and scientists themselves can continue to consider the profound impact of science communication.

A study limitation relates to the computing of classes because this task is partly dependent on the importance, in terms of volume, of a newspaper. This is for example the case of the Arizona Daily Star which represents 42% of the corpus studied. Future studies could include different experiments on sub-corpora, for example by excluding one or more newspapers, to compare the different classifications obtained. Concerning the automatic task of identifying the stakeholders, this one is based on graphical forms, but does not take into account pronominal anaphors and more generally lexical chains. Presently, this remains a challenge for NLP researchers, but recent

advances based on deep learning and word embedding (e.g., Simov, Boytcheva, and Osenova, 2017) can provide the means to make the identification of stakeholders and the computing of the SC score more accurate.

Also a limitation, during the construction of B2 (1987-1991) and its two missions (1991-1994), the Internet was in its infancy. Social media did not exist. More work is needed to explore the information diffused by online social networks in interaction with news media about scientific institutions.

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