Article

Monitoring Emerging Issues: A Proposed Approach and Initial Test

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Abstract

The increasing complexity and uncertainty of the future may stimulate demand for more monitoring emerging issues. Futurists have long advocated for monitoring the future on an ongoing basis or for tracking the findings of project work in practice. However, clients have historically been reluctant to invest time and money in monitoring, and little practical guidance is available on how to set up a monitoring. This article describes a pilot monitoring capability that is simple and practical to implement. It was developed as a "plug-in" to supplement an ongoing horizon scanning system. The monitoring system tracks the movement of emerging issues that were identified by horizon scanning. It provides a means to keep policy-makers informed about the progress of emerging issues and provides advance warning to develop an appropriate strategic response.

Keywords

Foresight, emerging issues, horizon scanning, monitoring

Introduction

The key objective of the Horizon Scanning project that the [author's] program co-created with the US Forest Service's Northern Research Station is to identify emerging issues that could affect forestry broadly (Hines et al. 2018). These are issues that have not yet been identified by decision-makers as requiring attention or a policy response. Emerging issues can exist at various degrees of emergence, from just identified and a long way off to on the verge of being current. Horizon scanning provides early warning of emerging issues, so that decision-makers can prepare for them before the issues fully emerge and affect the sector or industry (Callaway, Hines, and Bengston 2019). The practice of using horizon scanning to identify emerging issues is well established. For example, Sutherland et al. (2020) have published an annual horizon scan of emerging issues for global conservation for the last 11 years.

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To improve the usefulness of the horizon scanning system, a project was developed to add monitoring capability. Once emerging issues are identified, the proposed monitoring capability would track their development over time to see if they are maturing into current issues. The concept of emerging issue analysis (EIA) derives from Molitor (1977) who found that public policy issues tended to follow an S-curve shaped lifecycle. He developed a multistep model to forecast this emergence. Dator (2018) noted that EIA is based on the empirically validated fact that every problem/opportunity of the present at one point was an emerging issue. In this article, we will refer to problem/opportunity mentioned by Dator as a current issue. In order to identify what qualifies as "emerging," the scanning team must first be aware of what the *current* issues are for the client. Without a list of current issues, scanners—especially those from outside the organization—may have difficulty determining whether a scanning hit represents an emerging issue or whether it is well known and identified by or for decision-makers as requiring attention or a policy response, that is, a current issue (Callaway, Hines, and Bengston 2019).

A key question for the monitoring capability is: *Once an emerging issue has been identified, when does it become important or urgent enough to require consideration or action*? That is, *when does it move from an emerging issue to a current one?*

Monitoring essentially requires the same skillset and type of process as horizon scanning. The key difference in monitoring is that the search is focused on identifying signals of change or evidence focused on specific emerging issues, whereas horizon scanning explores more broadly for signals of change within the entire domain—in this case forestry. A key constraint for this project was that the horizon scanning was largely done by a small team of volunteers; thus, the proposed monitoring was designed to be practical so that it would not add too much work and overwhelm the volunteers. Another factor supporting the practical approach is that futurists have been advocating for monitoring with their clients for decades, but it has typically fallen on deaf ears (Hines and Bishop 2015). Understandably perhaps, after a Foresight project is over, participants go back to their "real jobs" and the recommended ongoing monitoring is neglected. Thus, it does not make practical sense to propose adding a time- and resource-intensive approach. These factors led to our choice of a simple and streamlined approach to monitoring. Our view is that the increasing complexity and uncertainty of the future (Fergnani et al. 2020; Nielson 2018; Scoblic 2020)_ may stimulate demand for more monitoring, potentially creating demand for a solution that is simple and practical to implement.

A few key concepts, indicators and time horizons, are explained below to help set up the analysis.

Indicators

A key focus of monitoring is on identifying specific indicators of the emerging issue that can be tracked. Indicators are, in effect, milestones or guideposts one would expect to see along the pathway from emerging to the current issue. Indicator identification and analysis is not a new concept. It is used in a variety of fields including economics, epidemiology, finance, performance management, sustainability, and development in general (Brown 2009; Economic Indicators n.d.; Gersl and Hermanek 2008; Marsden, Kelly, and Snell 2006; Spangenberg 2019; World Development Indicators 2020). Indicators are typically developed as quantitative measures. In Foresight practice, qualitative indicators are also used, given the fact that quantitative data about longer-term time horizons are less reliable and less easily developed than for the past or present.

Previous work (Hines and Bishop 2015, 128) defined indicators for Foresight applications as "signs or guideposts that suggest events are heading toward one or more of the alternatives [futures]." There are, however, many different definitions and uses of indicators depending on the field. One example of how indicators are used is in tracking progress toward health and development goals, such as the United Nations Millennium Development Goals (Hales 2010). Indicators are also used to track research

performance by measuring impact and quality of published works (Kosten 2016). A study looking at indicators in our domain of interest—forestry—used indicators to track progress in a forest planning optimization model (Maness and Farrel 2004).

There are several characterizations of what constitutes a good indicator. The descriptions can get very detailed. Hales (2010, 15–26) in "An introduction to indicators" provides a useful overview:

> *"A good indicator should be clear and concise. It should focus on a single issue that provides relevant information on a situation; particularly information that provides the strategic insight required for effective planning and sound decision-making.*
>
> *"Good indicators are also defined by the feasibility of collecting meaningful and credible data for them. In addition, good indicators should actually—and accurately—measure what they claim to measure. If it is not feasible to collect data for an indicator, or the data that can be collected is not meaningful, then indicator will have little or no utility."*

Hales (2010, 25) also notes that "there are very few indicators—if any—that are perfect." He suggests developing simple, useful indicators rather than aiming for perfection.

Time Horizon

Since the key objective of the monitoring system is to track movement of emerging issues over time, a framework was needed for this purpose. Molitor's (2018) Model of Change detailed a 22-step framework to track the development of public policy issues over time, from when they first emerged, to how they advanced, and finally to how they were resolved. This movement of issues over time aligns nicely with the Three Horizons model (Curry and Hodgson 2008; Sharpe 2013). The emergence of an issue begins in Horizon Three, advances to Horizon Two, and is resolved in Horizon One. Table 1 below provides a quick summary using an example of the long-term future of capitalism (Hines 2019).

Figure 1 graphically depicts the After Capitalism example. It shows the current baseline, Neoliberal Capitalism has moved from H3 to H2 and is now H1. The transition concepts of collaborative sharing platforms have moved from H3 and are now in H2. And the visionary concepts are still firmly in H3.

The arbitrary nature of selecting a specific number of years is recognized. Additionally, assigning a scanning or monitoring hit to a time horizon is admittedly an imprecise and subjective decision made by the scanner/monitor. In the case of this forestry project, the following timeframes were adopted:

- H1 = 1–5 years. The baseline or the system as it currently operates.
- H2 = 5–15 years. The emergence of plausible alternatives to the baseline.
- H3 = more than 15 years. A new system becomes the new baseline.

Table 1. Three Horizons Described.

Horizon	Description	"After capitalism" example
Horizon One (H1) most often the next 3–5 years	The current way the topic operates; the baseline future of continuity	*Baseline*: The current economic system of Neoliberal Capitalism
Horizon Two (H2) typically about 10 years out	The transition zone of potential disruptions to the baseline	*Transition*: Collaborative sharing platforms (the sharing economy, the collaborative economy, the platform economy, etc.)
Horizon Three (H3) is anything beyond H2, typically beyond 10 years	The zone of aspirations or visions of a new system to replace the current baseline	*Visions:* Sustainable Commons, Tech-led Abundance, and Non-Workers Paradise

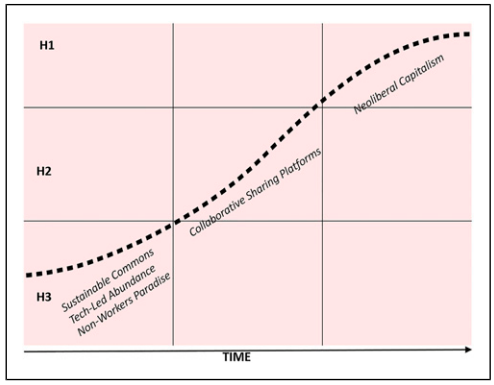

Figure 1. After capitalism on three horizons here.

When we speak of "movement," we are referring to this advancement of the issues along these three horizons. Emerging issues are typically situated either in H3 or H2. Current issues are in H1. The monitoring system is focused on tracking emerging issues in H3 and H2 to see if they are maturing into H1 current issues. As will be explained in more detail in *Testing the idea*, *A practical monitoring approach*, *Findings* below, our working definition of movement starts in H3, where the emerging issue is novel, infrequently mentioned, and often cited by fringe sources. At this point, it is generally of little interest to decision-makers. As it develops, it is mentioned more frequently—that is, we find more scanning hits—and by more credible sources. Thus, we say it has transitioned to H2. At this point, decision-makers begin to be interested—or perhaps should be. Finally, in H1, the issue is should be on the current decision-making agenda.

Literature Review

A diverse set of industries are already using indicators in a variety of ways, quantitatively or qualitatively, and therefore have developed some methods and guides for the monitoring process. Much of this work is in the context of scenario planning reported by well-known Foresight organizations, as well as in independent research studies, and in industry-specific studies. The insights extracted from these studies are mainly general guidelines of how to identify and find indicators for already developed scenarios, but they are also applicable to monitoring emerging issues.

In monitoring for scenarios, indicators are developed to track progress toward each of the scenarios. The major difference with indicators for emerging issues is in the scope. An emerging issue is more defined and bounded in comparison to a scenario. A scenario might include a description of how several emerging issues play out. The indicators developed for a scenario would generally need to be broader and more diffuse than indicators for a specific emerging issue. While this study is interested in monitoring and indicators for emerging issues, the insights and lessons from scenarios proved to be useful.

For two decades, Global Business Network (GBN) was a leading scenario consulting firm that offered several training courses in scenario planning which included monitoring. In their publication, "After the Scenarios, Then What?" GBN provided a guide for identifying and finding indicators in scenarios and what to think about in the process. They provided general guidelines rather than a specific process, suggesting that one revisit issues, driving forces, and uncertainties in crafting indicators (Gregory, Harris, and Ogilvy n.d.).

Another major player in the Foresight and scenarios space, Shell Scenario Team (2011) devoted one of its scenario publications to monitoring: "*Signals & Signposts*." They describe the application of indicators for specific future energy scenarios. They also provide very general guidelines for indicators by looking for descriptive "signals" (concepts, developments, initiatives, plans, etc.) to help explain each scenario in detail and "mark shifts." While the work provides a corporate perspective with real application, there is no concrete process identified.

An effort to bring a more quantitative approach to scenario monitoring originates in the work of He (2013) with his proposed seven-step process to build *composite indicators* to link with scenarios. Composite indicators are collection of several indicators for tracking a particular driving force, or, in our case an emerging issue. In view of our practical needs, this approach is far too detailed to be practical

for the client's small volunteer team. For those nonetheless interested in digging deeper, He's work was later critiqued and expanded upon by Xu (2014) with the observation that an ideal monitoring system would translate qualitative, categorical information into quantitative, numerical data. This work is worth keeping in mind for those with the budget and personnel to develop a sophisticated state-of-the-art system.

Hussain, Tapinos, and Knight (2017) looked at indicators for a scenario-driven roadmapping approach. It combines scenario planning with technology roadmapping, which involves creating a visual map of future pathway of a technology with intended milestones. They conceived of indicators as "flex points," or critical developments that signal transitions along particular pathways, such as the evolution of a certain technology. These flex points can be externally imposed upon the system or shaped from within in a direct or emergent fashion. The approach relies heavily on (internal) group discussion to develop the map. Hussain and colleague's advice to identify these flex points is similar in offering general guidelines—in this case, "considering potential key developments in the general environment at different periods up till the horizon set for the scenarios" (p. 166).

A portion of the literature comes from monitoring performance, progress, or development of a topic where the goal is to find a simple process and standard metrics for widespread use for a preferred (or improved) future. Similar to the scenario-focused literature, general guidelines are suggested rather than a set process, yet with more focus on the accuracy of the data over time. Marsden, Kelly, and Snell (2006), Spangenberg (2019) and Brown (2009) are examples of this approach, as outlined below.

Marsden, Kelly, and Snell (2006) reported on a study on performance measurement examining the use of indicators in local and regional authorities in the United Kingdom. The goal was to create a process for selecting a suite of indicators to support strategy development and monitoring outcomes, which they call preferred end states. A "good practice" guide for indicators is presented along with a hierarchical selection process:

1. Targets for key outcome indicators (direct measure).
2. Targets for intermediate outcomes (proxies or milestones).
3. Targets for contributory output indicators (contribute).
4. Targets for any other outcome or output indicators.

Marsden et al.'s report highlights the difficulty of consistently tracking indicators or performance measures in the long term (in this case year over year) due to changing and complex environments. Difficulties include topics subject to random factors such as air quality or accident rates, the longer time span of attitudinal changes such as consumer satisfaction, and random variations in automatically collected data. To solve this last issue, Marsden, Kelly, and Snell (2006) suggest collecting short-term data (here and daily) for more accurate long-term measures.

Spangenberg (2019) puts forth a critical assessment of scenarios and indicators for sustainable development and notes the need to balance the degree of scientific accuracy of the indicators given the availability of data and aligned to the purpose of needed policy advice. He also points out that the need for context-specific and locally driven indicators in the case of standardized categories is rarely realized because decision-makers' strong preference for quantitative versus qualitative indicators, which he calls "a fallacy of misplaced precision."

Brown (2009) provides general process guidelines in the use of indicators to monitor development and track progress in areas related to society, environment, and economy. Brown and colleagues outline five main stages in the development and reporting of indicators:

1. Establishing a purpose of the indicators.
2. Designing a conceptual framework.
3. Selecting and designing the indicators.
4. Interpreting and reporting the indicators.
5. Maintaining and reviewing the indicators.

Brown's process of creating a set of numeric and statistically sound indicators requires

extensive human involvement and involves multiple iterations including interested stakeholders and experts. The indicators are selected using a set of directional criteria, and because they are mainly public data points, they are in less need of construction or proxy numbers. In other words, Brown's indicator selection and review is mainly concerned with choosing indicators in the right context for wider public use (health data, GDP, HDI, etc.).

Issues Management

Since most of the monitoring and indicator literature regarding Foresight has focused on scenarios and preferred futures, the team explored the issues management literature to see if more guidance on processing advice for emerging issue monitoring could be found there.

Issues management emerged during the 1970s as organizations recognized the growing uncertainty of the future and sought to become more proactive in anticipating relevant issues (Chase 1984; Coates et al. 1986; Kosten 2016; Renfro 1987). Ihlen and Heath (2018) noted the importance of how the emerging issue is framed. The framing reveals how various interests are thinking about that issue.

The primary purpose in identifying emerging issues was to mitigate risks and prepare for industry changes. As emerging issue identification became prevalent, questions arose about how to usefully monitor them. Sources consulted for monitoring are not significantly different from horizon scanning, ranging across different media sources, scholarly discussions, social media, and blogs (Ihlen and Heath 2018).

Many different frameworks have been used to consider emerging issues, but they are mostly focused on identifying issues rather than monitoring them. Most involved some form of scoring process to determine whether the emerging issues merited consideration. Garnett et al. (2016) report examples of this approach. One firm uses the Delphi technique for evaluating and prioritizes emerging issues in terms of their potential future impact. Another also used teams of experts but not the Delphi. The weight of evidence is a quantitative method that assigns a weight or numerical value to each piece of qualitative data in assessing whether an emerging issue is worth considering.

Text Mining and Indicators

The development of big data analytics affords new opportunities in developing indicators. A few interesting, and more recent, sources were found around the use of text mining to track indicators.

Joung and Kwangsoo (2017) used a keyword-based model in their content analysis of patents to detect and monitor emergent technologies. One can imagine that this (and other) text mining tools and techniques applied in identifying clusters and matching of technical words (keyword context matrix) could also be adapted for identifying and monitoring emerging issues.

Krigsholm and Kirsikka (2019) also explored the use of text mining techniques, in their case for investigating future signals of the land administration sector. By applying concepts from recent literature on the progression of weak signals, their results included keyword emergence and keyword issue maps to unearth topics that are gaining momentum in the present. The literature reviewed included a three-dimensional chart of what Hiltunen (2008) calls a signification process, by which a weak signal grows from weak to strong. Lee and Park (2018) characterize movement across four types of signals based on change rate and frequency, from (1) latent to (2) weak to (3) well-known and finally to (4) strong. Similar to Marsden, Kelly, and Snell (2006) and Lee and Park (2018) note a potential judgment challenge of using a predominantly automated process here when trying to distinguish the types of signals.

The literature review described above provided some general guidelines for our project rather than specific process advice for the development of monitoring and indicators. It was useful in stimulating ideas about potential process steps that the team could then test.

Testing the Idea

To help develop process ideas for monitoring the evolution of horizon scan hits, the team

decided to trace the historical pathway of one of the emerging issues to see if or how it moved or matured over time. This required analyzing the hits in the scanning library, briefly described below. Next the emerging issues themselves are introduced. Concluding this section, we describe the "forensic analysis" approach we used.

Scanning Library

As noted above, the monitoring system was intended as an add-on to an existing horizon scanning system. In brief, the horizon scanning system employs a team of voluntary scanners and Foresight students to identify "scanning hits," which are individual articles, blog posts, videos, etc., that contain new, unique, and potentially disruptive ideas that could become emerging issues. The hits were collected in Diigo, a freemium cloud-based social bookmarking site. It provides a simple form-based approach to quickly capture, tag, and annotate web-based hits. In the 4 years, the Forest Futures Horizon Scanning system has been running, over 2000 hits have been collected.

The Emerging Issues

Reviewing the many horizon scan hits and prevalent tags in the Forest Futures Horizon Scanning system, we identified six key issues:

1. *Genetics in the Forest*: Should we, or how might we, integrate genetics and augmented or artificial design/approaches, such as synthetic biology, with the natural forest?
2. *Climate Migrants*: As climate change forces people to uproot and move, what will be the impact on rural economies and forests?
3. *Forests and Human Health*: To what extent will forests become part of the healthcare system?
4. *Climate-Induced Social Tipping Points*: What tipping points might flip climate social movements and attitudes?
5. *Coming Age of Wood*: How might high-tech advances in wood products bring about a new "age of wood"?
6. *Vertical Forests*: Are vertical forests a gimmick or signaling a way to integrate the forest more deeply into urban and daily life? "Vertical forests" are buildings with trees and other greenery integrated into their design.

Forensic Analysis

Before developing the monitoring process, the team decided to test the feasibility of tracking the historical movement of an emerging issue. A "forensic analysis" was carried out for the *Coming Age of Wood* emerging issue (Bengston, Hujala, and Butler 2019). Forensic analysis in social science involves "the careful compilation of evidence from unstructured digital traces as a means to generate new theories" (Goldberg 2015, 1)—or in this case scanning hits were compiled to support the identification of an emerging issue.

The first step was an attempt to identify the scanning hits in the Diigo Horizon scanning library related to *The Coming Age of Wood*. Fortunately, a "coming age of wood" tag had been developed that yielded 38 scanning hits. To be sure not to miss any, a broader more general search, including the terms "wood," "technology," "forest products," and "cellulose,",produced additional hits that were sorted through, yielding another 83 hits related to the issue, bringing the total to 121. One lesson here was the importance of developing a disciplined tagging system. Ideally, the 83 additional hits would have been tagged appropriately and saved in this additional step.

The next step was to look at the dates of the 121 hits to determine if the volume of hits was increasing or decreasing over time. Unfortunately, a limitation of the Diigo is that while it captures the date, the scan hit was entered into the database, and it does not capture the date of publication of the content. An analyst had to by manually add a data field and the publication date for the 121 hits (and this was another lesson: note the date in a scan hit, even if that must be done using a comment).

The team positioned *Coming Age of Wood* in Horizon 3 in 2014. A review of the scan hits at

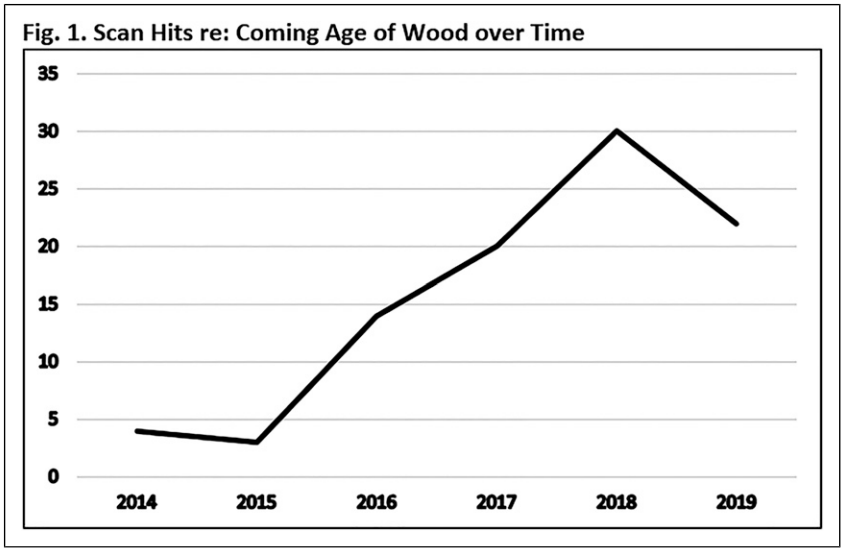

Figure 2. Scan Hits Re: Coming Age of Wood over time here.

that time suggests this was the case as they indicated that wood-based technologies were not the default choice compared to fossil fuel–based and mineral-based technologies. Figure 2 below shows the number of hits per year. This does not include two hits before 2014, two hits in 2020, and 24 hits for which a publication date was not determined.

The results suggest the *Coming Age of Wood* issue started out with very little content posted from 2012 to 2015, then leapt upward in 2016, again in 2018, and leveled off in 2019. It is important to note there is an element of subjectivity in these numbers as the scanners changed each semester and there may be style and performance differences, that is, some may have scanned more thoroughly than others.

In sum, the forensic analysis suggested that tracking the volume of scanning hits over time had the potential to be a useful way to detect the movement of emerging issues.

A Practical Monitoring Approach

The literature review and forensic analysis stimulated some process ideas. Several experiments were run, before settling on the following five steps:

1. Clearly define and bound the emerging issue.
2. Identify indicators as search terms.
3. Search for monitoring hits.
4. Keep non-indicator hits.
5. Collect and tag the hits.

Clearly Define and Bound the Emerging Issue

Ihlen and Heath (2018) noted the importance of how the emerging issue is framed since the naming of an issue is likely to suggest how the issue is being framed by the various interests involved. A classic example is the abortion issue, with opponents framing it as "right-to-life" or pro-life and supporters framing it as pro-choice. The project team sought to frame the issues in a neutral way.

Deciding how tightly to define an emerging issue is a key consideration. Both broad and narrow definitions were debated by the team. It was decided to try different framings rather than settle on a single standard. Thus, there was the very broad framing of *Genetics* (example below) to the very narrow *Vertical Forests*. We discuss our learning about this framing below. The emerging issues were titled in as few words

as practical, framed as questions, and then described in a paragraph. For example:

> *(Genetics) Increasing influence of genetics in the forest*
>
> ***Issue:*** *Should we, or how might we, integrate augmented or artificial design/approaches, such as synthetic biology, with the natural forest?*
>
> ***Description:*** *As gene editing knowledge and expertise grows, new species will be created and established species will be modified by synthetic biologic processes. In addition, engineered applications, such as artificial photosynthesis, may be integrated with the natural forest environment in the future. New regulations and resource management plans will need to be developed to balance competing priorities driving new technologies with preserving natural ecosystems.*

Identify Indicators as Search Terms

The scenario monitoring literature described above advises that about a half-dozen indicators are sufficient to monitor a scenario. Most common is to identify the key components of the scenario, the drivers of changes and develop indicators for the most important ones. Since an emerging issue is narrower in scope than a scenario, which might include several emerging issues, our intuition was that fewer than six indicators would probably be sufficient. Thus, our initial approach was to look for 3–6 key components of emerging issues and try to identify potential indicators from each.

Each team member was given two emerging issues to monitor. The process of selecting the indicators was iterative. Each indicator was tested by running a preliminary web search to see which returned the most relevant hits. A wide range of potential indicators to monitor were tested—from a low of three to a high of 15, before settling on a set to move forward with. In the spirit of experimentation, it was decided not to settle on the same number for each indicator and see what learning resulted from using different numbers of indicators.

In effect, the indicators would become search terms. Once you have indicator, you need some way to determine whether they are increasing. So the monitors we assigned to search articles, blogs, publications, etc. that had been previously identified by the scanning and specifically used the indicators as search terms. The results were then captured those in a new library in Diigo reserved for monitoring hits. Table 2 shows the indicator/search terms for the six emerging issues.

Table 2. Indicator terms for the six emerging issues.

Emerging issue	Indicators
Genetics (genetics in the forest)	Augmentation "Synthetic biology" "Artificial photosynthesis" Regulation GMOs
Migrants (climate migrants)	"Rural economies" Nomads "Land management" "Climate refugees" "Settlement patterns" "Distressed communities" "Natural disasters" "Extreme weather events"
Health (forest public and private health)	"Forest therapy" "Forest bathing" "Insurance" "Alternative medicine"
STPs (Climate-induced social tipping points)	"Social movements" "Political movements" "Climate protests" "Off-grid living"
Wood (Coming age of wood)	"Wood skyscrapers" "Cross-laminated" "Wood alternatives"
Vertical (vertical forest)	"Urban heat islands" "Stefano Boeri" "CO_2 reduction" "Mental health" OPEX

Table 3. Source by Time Horizon.

H3: idea creation	H2: elite awareness	H1: mainstream awareness
• **Specialty media (niche publication/blog)**	• **Scientific media (publication or blog)**	• **Mainstream media**
• **Scientific journal**	• **Industry/trade association**	• News
• Monographs	• **Govt/NGO**	• Periodicals
• Specialized periodicals	• Trade journals	• News, radio, TV, and internet
• Art	• Research reports	• Textbooks
• Fiction	• Newsletters	• Doctoral dissertations
• Fringe media	• "Dopesheets"	
• Underground blogs	• Popular tech journals	
• Speeches	• Newsletters	
• Technical journals	• Intellectual magazines	
• Social movements	• Books	
• Social media fringe (Reddit)	• Surveys	
	• Government reports	

Search for Monitoring Hits

We began this process instructing monitors to use the same search strategies and types of sources they employed for horizon scanning, with the exception of focusing on the particular indicators/search terms. But fairly early in the process, the team noted a pattern of particular sources generating more scanning hits than others. Thus, we decided to look for patterns in the types of sources over time.

We posited that if the sources of the monitoring hits could be classified according to the three horizons, then shifts in the types of source scan hits were found in could indicate a shift the emerging issue itself. The logic is that over time, the *types* of sources covering the emerging issue would shift as the issue moved or matured. In the beginning H3 sources would be prevalent. Over time, more H2 sources would start covering it, and finally H1 sources when the issue reached current status. In other words, as the emerging issue moved across time horizons, the type of sources covering would shift as well. The Houston Foresight program had developed a taxonomy of scanning sources sorted by the Three Horizons). The team compared these sources by horizon from the project to this taxonomy and then adjusted it slightly based on the scan hits in this project (Table 3). Table 3 bolds the key types of sources in each time horizon. As an issue emerges or coalesces in H3, it is primarily reported on in specialty media and scientific journals. As it more fully emerges in H2, the sources reporting on it shift to scientific media, and industry/association and government and NGO publications. Finally, the issue matures to a current issue and is reported on primarily in the mainstream media.

A field was manually added to Diigo for capturing the types of data source: that is, blog, scientific journal, industry association news, and mainstream media article. To test the utility of these bolded categories, the type of source was added for the most recent 20 hits in Diigo scanning library. The results are show in Table 4.

The distribution looked promising, so we decided to test it out on the *Coming Age of Wood* emerging issue hits (Twenty-five hits were excluded due to data issues). Overlaying both the volume by year and type of source, we found specialty media and scientific journals were the primary sources, shown in Table 5. Overlaying both the volume by year and type of source shows the following results:

The pattern that emerges suggests an evolution in scan hits from more niche/specialty

Table 4. Source from Most Recent 20 Diigo Hits.

Source	Horizon	Type of source
1. Yoga journal	H2	Newsletter
2. Housing theory and society	H3	Technical journal
3. UNEP science & data	H2	Government report
4. Plastic-free world.com	H2	Specialty pub (conference) from Special interest group
5. Oregon convention ctr	H2	Specialty pub (conference) from state government
6. Inside construction	H2	Trade journal
7. The architects newspaper	H2	Trade newsletter
8. ACS (Appl. Polym. Mater)	H3	Technical journal
9. Down to earth	H2	Blog (aggregator)
10. Yahoo finance	H1	News
11. Science alert	H2	Popular tech journal
12. Forbes	H1	Blog news
13. Euronews	H1	News (aggregator)
14. National geographic	H2	Popular tech journal
15. Floor Nature	H1	Company site
16. NJ MMA News	H1	News
17. Meetup.com	H3	Social movement
18. Tech Xplore	H2	Blog (technical)
19. Nature connection guide	H2	Technical non-profit site
20. Gizmodo	H3	Blog (future-oriented)

Table 5. Scanning Hits by Source.

Year content posted to web	Total no of hits	Specialty media	Scientific media	Scientific journal	Industry assoc. article	Mainstream media	Govt/ NGO
2014	4	3			1		
2015	3	1	1		1		
2016	14	4		3	4	1	2
2017	20	11		5	3	1	
2018	29	9	5	8	2	3	2
2019	27	9	5	7		6	
Total	**97**	**37**	**11**	**23**	**11**	**11**	**4**

sources in 2012–2015; to an inflection point in 2016 where other sources start to publish about this topic—including in scientific journals and industry association publications; 2018 is the point when slightly more scan hits come from a mainstream media sources. By 2019, there are fewer content items created in niche sources, and more in established institution sources—with six items created by mainstream media.

The analysis above and in Table 6 suggests that the *Coming Age of Wood* has crossed the threshold from H3 to H2. In this forensics example, the scanning hits showed the controversy about the viability of wood-based technology solutions, with some beginning to be commercialized and threaten legacy industries.

More work needs to be done to test the validity of whether the sources indicate a particular time horizon. Clearly, specialty media sources can be found in all three time horizons. It is likely that the six categories were too broad. Specialty media, for example, is a

Table 6. Coming Age of Wood Forensic Monitoring Timeline.

2012–13 (2)	• Specialty media scan hits in Treehugger blog and Gizmodo speculate on new technologies using wood as the base material – tall wooden skyscrapers and 3D printing • Mention of Michael Green "giving away the technology"
2014–15 (7)	• Four hits in specialty media; 2 in industry association • Controversy over safety of tall wood building surfaces—wood alternative to steel and concrete discussed and questioned • Additional advanced technologies using wood appear: batteries, silicon chips, and nanocellulose • Wood-based nano technology terminology
2016 (14)	• First mainstream media scan hit from CNN: "Will timber define our age?" • 2 entries from government publications show increasing funding and support • Continued controversy in industry • Scientific advances using nanocellulose: glass alternative, jet fuel, and biomedical
2017 (20)	• 1 mainstream media scan hit on future impact of wood-based fibers on garment industry • 11 hits in specialty media reviewing advances in wood-based technology = tires, energy transfer flooring, fabric, car parts, desalination, and graphene • 3 industry association hits on companies commercializing new wood products • Michael Green referenced as "pioneer" in tall wood buildings industry/use of CLT
2018 (30)	• 3 mainstream media hits: Fast Company, Seattle Times, and Deutsche Welle article makes generalizing statement "Experts around the world agree that bio-based products are essential for a sustainable society" • Significant hits from scientific journals (results from academic funding prior to 2018) • Government Pub from European Forest Institute makes case for bio-based circular economy
2019 (27)	• 6 mainstream media hits summarizing Mass timber/CLT/skyscrapers as the future: Forbes, Washington Post, Bloomberg, Guardian, and National Geographic • Continuing build of scientific journal hits on advances for cellulose in new materials—more scientists engaged and publishing • Canada building codes implemented across country for tall wood buildings • Pushback by US concrete industry over safety of tall wood buildings

broad category that could likely be broken down into H3 specialty media sources and H2 special media sources, with an adjusted nomenclature to distinguish the two. Similarly, some scientific journals are technical and more likely to indicate H3 while others indicate H2.

Keep Non-Indicator Hits

We decided that if during the monitoring, a "hit" related to the emerging issue was found—but was not specific to one of the indicators—we would still capture it. While the indicators were the primary focus, it could be that a development not captured in an indicator could also shift the prominence of the emerging issue. That is, there could be a new development within the emerging issue that raised its importance. One could imagine in such a case that a new development might be captured by adding a new indicator but that did not occur in the relatively short few months in which this pilot ran.

Collect and Tag the Hits

The existing horizon scanning library in Diigo had roughly 2000 hits. We decided that it would be easier to start a separate library for the monitoring, so that the comparatively small number of monitoring hits would not get "lost" in the larger library. The initial idea was a fairly simple approach to standardize the tagging process:

- 1st tag is the emerging issue, for example, "*Coming Age of Wood.*"
- 2nd tag is the indicator, e.g. "wood skyscrapers."

- 3rd tag is something specific to the article, for example, "Norway."

As the monitoring hits were identified, the need to agree on a tagging scheme and get an accurate count quickly became evident. Just slight variations in the wording of the tags would diffuse the number of hits. For instance, the tags "tall wood buildings," "plyscrapers," and "wood skyscrapers" were all indicating the same thing. By agreeing on "wood skyscrapers" as the tag, the count would show three hits. In setting up a horizon scanning database in previous work, it was learned that inconsistent tagging required later cleanup, which was an onerous task. Being consistent up front saves time and gives a clearer picture of what is happening in real time (however, the volunteer nature of the Forestry Futures Horizon Scanning project may always require cleanup and review by project managers). After some preliminary data analysis, we developed a more sophisticated tagging system and captured it in a tagging dictionary, depicted in Table 7 below:

The columns are described below:

- Time horizon: the objective is to see if there is a shift in timeframe about the emerging issue or its indicators; for example, is it still showing up primarily in H2 and H3, or is it starting to show up in H1?
- Source: Certain sources of information are oriented toward a particular horizon, that is, there are typical H3 (sci fi), H2 (popular technology publication, such as Wired), and H1 (newspapers) sources. Similar to time horizon, is there a shift in which type of sources are talking about the emerging issue?
- Emerging issue: create a keyword for tagging each emerging issue.
- Tags: create standard keyword tags relating to the indicators developed for each emerging issue.
- Article-specific: a keyword or two specific to the article.
- Date of publication: for data analysis purposes, when exporting to Excel, it is more convenient to add the date publication as a comment. Again, our intent is to see what patterns emerge over time.

As in qualitative data analysis, it became clear that it is not possible to set up the "right" system at the start as there is an element of ongoing experimentation that necessitates refining the tagging system (Miles, Huberman, and Johnny 2020). The team had weekly meetings to assess progress and make any agreed-upon adjustments.

Findings

The intent of this project was to propose a conceptual model that would prove interesting enough to stimulate further research. A fully realized monitoring process is not possible in the

Table 7. Tagging dictionary terms.

Time horizon	Source	Emerging issue	Tags	Article specific	Date of publication
H1, H2, or H3	Specialty media Scientific journal Scientific media Industry/Assn pub Govt/NGO pub Mainstream media	Genetics Migrants Health STP (social tipping points) Wood Vertical	See Table 2 Indicator terms		Add as comment, format: 16-MAR-2020

timeframe of this project (an academic year). Nonetheless, we can provide some preliminary observations and suggestions for further research.

There were 110 monitoring hits captured in the Diigo database. It is worth noting that the team saw a clear drop-off of hits in monitoring general due to COVID-19 in the Spring 2020. The horizon scanning team reported the same drop as well. Coverage of the pandemic overwhelmed the attention to other issues. We had 59 monitoring hits for Horizon 1, 39 for Horizon 2, and 12 for Horizon 3. This ratio by horizon is not much different than that for the horizon scanning database. The relatively low percentage of H3 hits makes sense, although the ratio of H1 hits is higher than expected for monitoring. This would suggest that at least a few of the emerging issues are getting close to crossing over to being current issues.

The monitoring hit count by emerging issue:

- Coming Age of Wood 32
- Forests and Human Health 20
- Climate Migrants 16
- Vertical Forests 15
- Genetics and Forests 14
- STP (social tipping points) 10.

It is not surprising to see the *Coming Age of Wood* with the most hits as it was perhaps the most broadly defined of the six. *Vertical Forests* was the most narrowly defined, but its relatively high number of hits might owe to strong public relations capabilities/coverage. The emerging issue coming in lower than one might have expected was genetics, particularly since it also included synthetic biology. The initial monitoring of this issue did return a large number of hits about genetics in general. The monitor was then tasked to only include hits that specially mentioned a connection to forestry. This brought the volume of hits down to a more manageable number. In more general scanning, hits that could logically connect to forestry without specially mentioning it would likely be included. Handling the scoping of the emerging framing will need to be experimented with and tested over time.

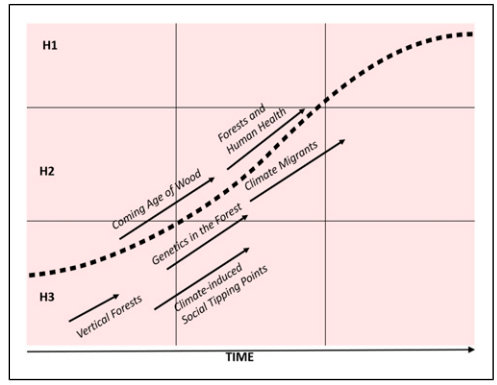

Figure 3. Movement of the six emerging issues here.

Observed Movement of the Issues Across the Horizons

Figure 3 below is an approximation of the team's view of how the six emerging issues have "moved" since 2016, when the horizon scanning system was set up. In the graphic, the issues move up the curve over time. The vertical lines represent approximate thresholds between the horizons.

The movement of each issue depicted in Figure 4 is briefly characterized below.

- *Genetics in the Forest*: moved from H3 firmly into H2; the genetic aspects are moving "faster," but the inclusion of synthetic biology began more deeply in H3 and has moved more slowly; thus, the overall movement was judged to be somewhere in the middle of H2.
- *Climate Migrants*: began on the edge of H3/H2 and has been moving steadily toward H1 but not quite there yet.
- *Forests and Human Health*: probably moved the most of the six; "forest bathing" in particular has moved from H3 to near H1, while some other aspects are moving more slowly.
- *Climate-Induced Social Tipping Points*: similar trajectory to Genetics, moving from H3 firmly into H2.
- *Coming Age of Wood*: similar trajectory to Genetics as well but seems to have

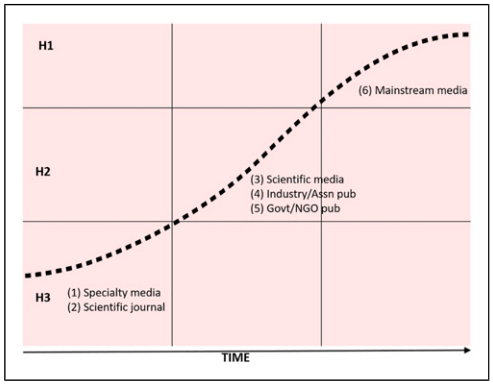

Figure 4. Relationship between scanning source and Time Horizon here.

advanced further, in particular driven by great use of cross-laminated timber.

- *Vertical Forests*: move the least of the six issues, remaining in H3.

Some Project Observations

The literature review proved disappointing from a practical standpoint. Most sources provided general guidelines rather than specific process advice. In cases where there was process advice, it was often highly detailed and time- and resource-intensive. Thus, more time was spent investigating and developing a process rather than testing it. Perhaps the key point to be made here in considering setting up a monitoring system is to be acutely aware of time, budget, and capability constraints. Our prior knowledge of the client provided a useful back-of-the-envelope understanding of how "deep" we could go. That is, as certain activities were considered, they were aligned with the client needs. For instance, composite indicators, discussed above, were seen as interesting but not practical for the client to implement.

As was the case with previous work in setting up a horizon scanning system, the Three Horizons framework provided an extremely useful framework for considering the potential "movement" of emerging issues over time. The horizons provide a useful conceptual threshold for characterizing this movement. The coalescing of weak signals in H3 crosses over to an emerging issue in H2, which in turn eventually crosses over to a current issue in H1.

The forensic analysis of the *Coming Age of Wood* emerging issues proved fruitful. It triggered several process ideas that were later adopted. It also led to the rather unique idea of looking at types of sources for potential clues on how emerging issues evolve. The preliminary work is quite rough and the results suggest much work needs to be done, but these preliminary results are promising.

The creation of the tagging dictionary was a significant help to the monitors. The creation of agreed-upon types of tags, key words, and even the order of tagging made the job of the monitor much easier and analysis much smoother. There was still some "cleanup" that had to be done, but that is a given, especially with a team contributing to the dataset.

Overall, the team felt that the proposed process seemed to find an appropriate balance between practicality and utility. It seemed reasonably simple to do—and ultimately to teach to new monitors—but also seemed to produce interesting insights.

Challenges

Several challenges became apparent that will require additional study:

1. With broad issues like *Genetics*, for example, how does one avoid getting lost in "all" new possibilities for genetics applicable to forestry? It may be a more compelling monitoring hit if the article itself made the connection to the emerging issue than if the scanner/monitor makes the connection.
2. Many specialty publications, currently in H3, are actually reporting on H2 and even H1 events or developments, for example, a blogger reports on a technical science journal article that would not otherwise likely be encountered. More work needs to be done in evaluating how well the publication categories align with the suggested time horizon.

3. If "other" non-indicator hits are allowed when monitoring, does this put the team back into scanning? Is there a need to put tighter constraints on monitoring, that is, sticking to just indicator-related hits?
4. How does one ensure that the scanning process is aligned with the monitoring process and with the tagging dictionaries? If new tags are required, it is important to revise both processes in parallel for greatest success in the subsequent data analysis stage.
5. Should an established horizon scanning team simply add monitoring to their work, or should separate teams be established for each?
6. Diigo has proved to be an excellent tool overall, but there are some limitations. An "ideal" monitoring software might include:
   A. Inputs
      i. Able to set up automated scrapes for defined content from web searches, social media platforms, or any other form of online article repository and export it into the monitoring database using smart AI to put the following parameters into data fields: Date article posted, author, URL, title, first paragraph of article.
      ii. Able to define drop down data fields to aid human monitors in tagging all inputs in the same order and with the same tags (no changes to capitalization, spelling, etc.). For example, a drop-down selection menu for sources would have all the source categories so the person entering the content would not have to manually type in "industry assn publication." This improvement would eliminate potential variations, such as "industry pub" versus "industry_association pub."
      iii. Able to identify "double" entry of same content that is being reposted in another source and label it as duplicate with a link to the first entry of that same content. This would eliminate double counting of content when conducting analyses on the database.
      iv. Able to add "help" or drill down descriptions to any tags to aid monitoring team in how to apply tags, for example: "wood alternatives" = "wood alternatives are advanced technology materials being derived from wood components such as cellulose and lignin. Examples include textiles, batteries, and electronic conductors."
      v. Ability to "find and replace" a tag with an updated tag without going to each individual entry.
   B. Analysis and Data Visualization
      i. Built-in tool that would chart the number (volume) of tag hits over time.
      ii. Graphing capability for visualizing data analyses for creating cross-tab charts of number of hits with source or with horizon tag to create visual of how tagging is/is not evolving over time.
      iii. Built-in tool that enables natural language text processing or searching of all main body content to discover "key words or phrases" that help define the indicator or point to a new emerging indicator.
      iv. Built-in tool that would enable correlation analysis of key words—simple relationship of how often key words occur together in the content being scraped and monitored. For

example, in the *Coming Age of Wood*, such analysis could point to whether the key words "cellulose" and "nanomaterials" highly correlated.

C. Outputs
   i. Ability to easily export built-in charting or cross tabs into presentation software.
   ii. Ability to easily export data and data fields into Excel (or other database platforms) for further analysis or visualization charting.

Conclusion

Exploring and developing processes to effectively monitor emerging issues is important for several reasons: (1) clients need it to make sense of horizon scanning data and it is likely clients would be willing to invest in it and (2) there has not yet been sufficient attention and process guidance available on how to monitor effectively.

This project centered on developing a process for monitoring because this was lacking in the Foresight literature. The development of the process led the team in several interesting research directions that are but briefly highlighted here. The "forensic analysis" surfaced several insights into the process and reinforced the critical importance of standardizing terminology and approaches as soon as practical. This in turn led to the development of the tagging dictionary that we judged an invaluable tool for aligning the team. The forensic analysis also sparked an investigation into the possibility of using the type of source as an additional means to track the movement of issues over time. While it is clearly a work in progress, we were excited about its long-term potential to give a quick look at the progress of an issue from far-off to imminent impact. There is much further work to be done. For instances, three interesting research questions come to mind:

- the increase in the number of monitoring hits is assumed to be indicative of movement, but it may be the case that those indicator terms may point to the evolution, expansion, or transformation of the emerging issue rather than its movement toward current issue.
- What does the shape of the movement across the horizons look like? It is likely that some emerging issues stay in H3 longer and some might move more quickly.
- What is the role of hype? It could draw on the work of Gartner's Hype Cycle.

The team worked well within the constraints of the Diigo library tool, but this also led to the development of a significant and detailed set of parameters for what an ideal monitoring software might look like.

The simple five-step process recommended is offered as a robust "starter" approach in the relatively brief semester-long trial. Indeed, it is offered in the spirit of a pilot that can and should be adapted and further developed. Most of the findings reported on in this piece are preliminary. It is our hope that presenting these early ideas will help to stimulate interest in monitoring and indicators. There is plenty of work to do.

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