Nature Inspired Guidelines to Effectively Communicate Sustainability Messages

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Abstract:

Communication patterns in nature were studied in order to address the challenge of effectively communicating sustainability messages. Fourteen patterns were found in nature and translated into user-friendly guidelines called Guidelines for Effective Communication of Sustainability Messages. These Guidelines were given to sustainability experts and peers for overall feedback and insights. Their responses showed that these Guidelines could be used to improve communication of sustainability messages by using them as a checklist and a design tool when designing messages and methods for communicating sustainability. Using these Guidelines as a tool within the Framework for Strategic Sustainable Development (FSSD) could also help people better understand today’s sustainability challenges and the need for adopting a strategic approach used within the FSSD.

Keywords: Biomimicry, effective communication, FSSD, nature, strategic sustainable development, sustainability messages.
Statement of Contribution

The research and writing of this thesis was a collaborative effort where our individual perspectives, strengths and expertise provided major contributions to this paper. Both our diverse and shared backgrounds provided a solid foundation to work from throughout the research and writing processes.

Andrea and Maya brought their existing knowledge of the biological sciences from their undergraduate degrees, while Heather offered knowledge and professional experience from the advertising and marketing world. All of us brought our love of nature to help complete this report.

We all shared responsibilities, workload and contributions evenly. All three of us cooperatively shared in: the design structure, literature reviews, contacting experts, analysis, writing and editing. Credit however goes to: Andrea for formatting spreadsheets; Heather for formatting documents; and Maya for creating figures.

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We wish to thank our primary advisor Merlina Missimer for her insightful critique, advice and guidance when reviewing our paper and ideas. The confidence she showed in our abilities to bring this new idea of communicating sustainability by emulating nature’s patterns was invaluable.

Our thanks also go to our secondary advisor Tony Thompson for his sound comments and advice, his enthusiasm and his interest in our use of Biomimicry in this paper and of course his time to review our paper.

During this entire process Megan Schucknecht, of the Biomimicry Institute, generously provided time out of her busy schedule to speak with us, answer our many questions and provide us with important feedback and information. We sincerely thank Megan for this invaluable contribution.

We are also incredibly grateful to Mayra Ortega Maldonado of the Biomimicry Dutch Organization for her incredible patience and generosity when creating the opportunity for us to attend the Biomimicry Workshop in Eindhoven. This experience became the cornerstone to our research paper.

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Executive Summary

Introduction:

In spite of the growing consciousness surrounding climate change, other sustainability issues and the urgency in which actions need to be taken, the message is not reaching people either quickly enough or in a way that results in the needed policy and behavior changes. So it begs the questions, how are people communicating these messages and is there a way to make the communication around sustainability more effective?

Nature offers many examples of communication patterns and methods that are efficient and effective. Biomimicry is a term used to describe emulating nature as a model to solve human problems (Benyus 1997). It encourages people to look at nature, learn from it, and apply those lessons to design successful and sustainable solutions. Despite differences between human and other species’ communications, it is possible that successful communication patterns in nature hold lessons that may help to improve human communication.

Framework for Strategic Sustainable Development (FSSD):

The overall aim of this study is to help move society towards global socio-ecological sustainability. In order to provide a strategic approach and a whole systems perspective, the Framework for Strategic Sustainable Development (FSSD) is presented. Using the FSSD requires a clear definition of the system: the biosphere that encompasses society and the exchanges of materials and flows between the two. Once the system has been established, a clear definition of success becomes apparent: achieving global socio-economic sustainability. The definition of success, provided by the four Sustainability Principles, is comprehensive, science-based and concrete; describing the conditions required for a sustainable society (Robèrt and others 2007).

Inspiring organizations and individuals to adopt the FSSD can be challenging because messages around sustainability are often confusing, not effective enough to create action or are just not reaching the intended audience. Taking nature’s examples of successful communication patterns
and using them to help communicate sustainability messages more effectively, could assist people in recognizing the importance of using a strategic framework such as the FSSD that will help them progress towards a more sustainable society.

**Purpose, Research Question and Scope:**

The purpose of this research is to encourage sustainability practitioners and others who want to communicate sustainability to look at nature for inspiration when designing and delivering sustainability messages. Furthermore, this research seeks new insights and recommendations regarding more effective ways to communicate sustainability messages by emulating communication patterns that are used in nature. To do this, the following research question was asked:

**How can communication patterns observed in nature help to effectively communicate sustainability messages?**

It is important to note that the scope of this paper does not include looking at existing communication theories in human society because the research methods used in this paper specify to first look at nature’s examples with the purpose of finding new lessons to be learned from nature.

**Methods:**

The Biomimicry Guild’s Life’s Principles framework and Biomimicry approach were used. The overall process of the research consisted of six main stages:

- **Stage One:** Preliminary Literature Review, Information Gathering and Analysis
- **Stage Two:** Identification of Communication Patterns in Nature
- **Stage Three:** Feedback on Underlying Patterns
- **Stage Four:** Development of Guidelines for Effective Communication of Sustainability Messages
- **Stage Five:** Feedback on Guidelines for Effective Communication of Sustainability Messages
- **Stage Six:** Feedback Integration and Compilation of Guidelines
Results:

To derive the Underlying Patterns of Communication in Nature, six functions were identified for effective communication: attract attention (AA); information exchange (IE); direct behavior (DB); incentivize behavior (IB); maintain behavior (MB); and decision making (DM).

These functions were used with the Biomimicry approach to identify the 14 Underlying Patterns of Communication in Nature from which 14 Guidelines for Effective Communication of Sustainability Messages were created with associated keyword(s). Each Underlying Pattern is identified below with the corresponding Guideline and keyword(s):

1. **Audience. Desired Actions.**
   - Pattern 1: Match the signal to the receiver and the desired actions.
   - Guideline 1: *Understand your audience and what you want them to do.*

2. **Context/Environment.**
   - Pattern 2: Adjust the signal to environmental conditions.
   - Guideline 2: *Adjust the message and the way it is sent based on environmental conditions.*

3. **Proximity.**
   - Pattern 3: Consider proximity or spatial distance when sending a message.
   - Guideline 3: *Consider proximity when sending your message.*

4. **Timing.**
   - Pattern 4: Design a signal that is appropriate to the timing of the receiver.
   - Guideline 4: *Make sure the timing of your message is appropriate.*

5. **Networks. Win-Win.**
   - Pattern 5: Utilize close relationships and promote mutualistic interactions.
   - Guideline 5: *Use your networks and make interactions rewarding.*

6. **Decentralized.**
   - Pattern 6: Spread messages using decentralized and distributed information.
• Guideline 6: Keep it local and spread it out to more than one source.

7. Feedback.
• Pattern 7: Create short feedback loops.
• Guideline 7: Create an interactive exchange of information within short time periods.

8. Simplicity in Combinations.
• Pattern 8: Create a message using simple components in different combinations.
• Guideline 8: Remember that messages can be created using simple components in different combinations.

9. Resourcefulness.
• Pattern 9: Be resourceful and use what is available.
• Guideline 9: Be resourceful and use your skills, tools and existing materials.

• Pattern 10: Use methods that do not create unusable waste.
• Guideline 10: Be innovative and find ways in which waste equals food.

11. Optimization.
• Pattern 11: Conserve energy and/or optimize energy use.
• Guideline 11: Optimize energy use.

12. Repetition.
• Pattern 12: Send the same message more than once.
• Guideline 12: Repeat the message.

13. Variation.
• Pattern 13: Send the same message using more than one method and/or multiple signaling.
• Guideline 13: Vary the way you send the message.

• Pattern 14: Consistently use the same message in a certain context.
• Guideline 14: Consistently use the same message in the same situation.

Discussion:

Guidance and support received from the Biomimicry Institute strengthened the validity of the research design and methods. In addition, both the 14 Underlying Patterns of Communication in Nature and the Guidelines for
Effective Communication of Sustainability Messages were reviewed by external experts and modified according to their relevant comments. However, time and limited access to experts were seen as constraints. If more time had been available, a larger number of organisms would have been researched, which could have resulted in identifying more Underlying Patterns; and if a larger number of expert reviewers had responded, it would have helped to strengthen both the Underlying Patterns and Guidelines.

Based on the overall observations and research of the authors, there were some patterns that show promise for improving human communication by introducing new or forgotten ideas into sustainability communication strategies. Examples of these patterns include: create short feedback loops; create a message using simple components in different combinations; use methods that do not create unusable waste; and conserve energy and/or optimize energy.

It is important to understand that following the Biomimicry Guild’s Life’s Principles framework does not fully ensure a sustainable outcome. Although one of its main goals is to promote sustainable solutions to human challenges, the Biomimicry discipline does not entail a clear definition for sustainability. Therefore it is necessary to use the Guidelines developed in this paper in conjunction with the four Sustainability Principles within the FSSD. Used as a tool within the FSSD, the Guidelines can help in the process of moving society towards sustainability.

Nature inspired communication methods could enhance understanding the importance of sustainability issues, promote awareness and increase people’s willingness to take an active approach towards sustainability. This could be achieved by using the Guidelines and also because nature inspired communication can remind people of their connection to the natural world and inspire a new worldview.

**Conclusion:**

The Guidelines presented here are a way to improve human communication when creating sustainability messages. They encourage taking a humbling approach of seeing nature as a mentor rather than as a supplier, as well as adopting an interconnected worldview. Both are habits that are urgently needed to help move society towards global socio-ecological sustainability. Using nature inspired communication methods based on these Guidelines within the FSSD could create synergistic interactions between them.
Glossary

**Backcasting**: a planning procedure in which a successful outcome is imagined in the future, followed by the question: “what do we need to do [now] in order to reach this outcome?” (Holmberg and Robèrt 2000).

**Biomimicry**: “imitation of life” - a new discipline, term and concept that focuses on emulating nature as a model and a source of inspiration to solve human challenges. Biomimicry encourages people to look at nature’s champions, all a result of millions of years of evolutionary selection, learn from them and apply those lessons to design successful and sustainable solutions (Benyus 1997).

**Communication**: in its broadest meaning, is the exchange of information occurring when signals given by an individual (the *sender*) influence the behavior of another (the *receiver*) (Bradbury and Vehrencamp 1998, 354).

**Context**: the general situation in which the communication occurs (Bradbury and Vehrencamp 1998, 358). It includes many different variables such as cultural, time, weather, location etc.

**Effective communication**: spreading a message in a way that makes it memorable for the receiver and affects his/her actions in the long term.

**Form**: the way in which the signal is transmitted, e.g. calls or sounds, eye contact, written language, colors, body language, etc.

**Life’s Principles**: principles developed by the Biomimicry Guild to help scope, evaluate and apply successful strategies in nature to human design. The six Life’s Principles describe universal characteristics of natural processes that according to the Biomimicry Guild’s approach could lead to more sustainable human design methods (Biomimicry Guild 2010).

**Message**: the information a sender encodes in a signal (Smith 1968).

**Nature**: the authors use this term to refer to all non-human living organisms and processes, from the cellular level to ecosystems. Although humans are part of nature, this paper aims to find strategies and inspiration outside of human society, in other living creatures and processes.
Signal: any action or trait generated by the sender to provide information to the receiver and meant to influence the receiver’s behavior (Bradbury and Vehrencamp 1998; Johnstone 1997). Signals vary immensely and make use of different sensory channels: visual, acoustic, chemical, mechanical and electric (Scott 2005).

Sustainability Principles (4SPs): Four Sustainability Principles that offer a science-based, operational definition for socio-ecological sustainability on a global scale (Holmberg and Robèrt 2000; Ny and others 2006).
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1 Introduction

“Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.”
(IPCC 2007)

There is an extensive amount of scientific evidence that climate change exists in large part due to the activities of human society. Current research also details the likely effects global warming currently has, and will continue to have on the biosphere. However, climate change is only one in a long list of environmental and social challenges that humanity faces today: mass extinction, habitat and biodiversity loss, resource scarcity, poverty, oppression, etc. (Millennium Ecosystem Assessment 2005).

“It becomes crystal clear that the problems of our planet are highly interlinked - without combating climate change we will fail to stop the loss of biodiversity, without protecting ecosystems with their carbon storing capacity it will be extremely difficult to meet climate change targets. And without both of them we will fail in our efforts to fight hunger in the world!”
(Secretariat of the Convention on Biological Diversity 2010)

The interconnectivity of ecological, social and economical impacts is often undermined and the above challenges are viewed as separate problems. For many people, sustainability is not a clearly defined concept and is often used interchangeably with environmentalism. This, too, contributes to a limited view in which environmental and social issues are understood as isolated challenges with isolated consequences. As resources are becoming more scarce and societal conflicts are increasing, individuals, groups and society as a whole need to become more aware of these issues and begin implementing sustainable behavior. Getting people to first recognize the interconnections of the environment, society and economy, then act accordingly is one of today’s sustainability challenges.
1.1 The Communication Challenge

In spite of the growing consciousness surrounding climate change, other sustainability issues and the urgency in which actions need to be taken, the message is not reaching people either quickly enough or in a way that results in the needed policy and behavior changes. So it begs the questions, how are people communicating these messages and is there a way to make the communication around sustainability more effective?

“The problem with communication… is the illusion that it has been accomplished.”

(George Bernard Shaw)

In today’s world of the internet, email, video conferencing, instant messaging, cell phones, social networking sites, open source technology, mass media, satellite communication, etc., it is safe to assume that human communication is unique in its scale, speed and means. However, as advanced as it is, human communication is not perfect. Communication barriers still occur and create confusion between the sender of the message and the receiver. In addition, overload of rapidly changing and often contradictory messages may create confusion and may lead to unsustainable, short-sighted decisions. Lack of response may also occur even when messages are sent with “urgent” priority. This may be because more information is needed before an individual reacts to a message (Wardekker 2004). Moreover, an idea that requires a behavioral change takes more than knowledge and awareness of the need, but also a persuasion by trial and interactive communication with other individuals (Rogers 1995). Evidence shows that most people respond to information learned experientially rather than analytically, despite the fact that analytical information may be more reliable (Marx and others 2006).

“…even the choice of a single word can make the difference between winning and alienating an audience.”

(CRED 2009)

Knowing how people respond to information is especially important when relaying urgent issues of sustainability. The Center for Research on Environmental Decisions (CRED) at Columbia University recently published a guide that describes common mistakes communicators of sustainability unconsciously make. The guide offers research results that
show how people respond to certain words or phrases regarding climate change and how the reaction can be short-lived depending on the way the message is delivered (CRED 2009). In further understanding communication, it is important to realize the vital roles form, content and context play in the effectiveness of the message. Examples of forms used in communication are: eye contact, written language, colors, body language, etc. Content is the type of information that is being relayed and context could include environmental, economic and social circumstances that influence the sender or receiver. Each one of these factors can influence the effectiveness of the other. The consideration of the audience when designing the message’s content and form is another important factor.

1.2 Emulating Nature

“Trust one who has tried it, you will find more in woods than in books; trees and stones will teach you what you can never learn from masters.”
(Saint Bernard de Clairvaux)

Nature offers many examples of communication patterns and methods that are efficient and effective. The University of Illinois studied bees and ants and found that messages can be relayed quickly and more accurately in their colonies than when compared to human society (Aldunate and others 2005; Kostoulas and others 2007). A study from the University of Illinois mimicked these communication patterns to create a model that will result in more trustworthy and effective communication methods in disaster relief operations. Furthermore, swarm intelligence was studied and copied by Southwest Airlines to change their costly and relatively disorganized cargo operations into an efficient system that also increased profits (Bonabeau 2001). Swarm intelligence is “a collective behavior that emerges from a group of social insects [and] results in efficient solutions to difficult problems” (Bonabeau 2001, 105). Both of these cases are excellent examples of using successful communication patterns in nature to improve and increase the efficiency of behavioral patterns and mechanisms in human society.

Biomimicry is a term used to describe emulating nature as a model to solve human problems (Benyus 1997). The rationale and beauty of this concept is that living organisms have had millions of years to adapt to changing conditions throughout evolution, creating successful solutions to most of the challenges that the human species is facing as well (The Biomimicry
Institute 2010). Biomimicry encourages people to look at nature, learn from it, and apply those lessons to design successful and sustainable solutions.

The Biomimicry framework is based on six “Life’s Principles” identified by the Biomimicry Guild as universal characteristics of natural organisms, processes and ecosystems. These six Life’s Principles are:

- **locally attuned and responsive;**
- **integrates cyclic processes;**
- **resilient;**
- **benign manufacturing;**
- **leverages interdependence;**
- **optimizes rather than maximizes** (Figure 1.1). See Appendix A for definitions.

![Figure 1.1. Biomimicry Life’s Principles Framework (The Biomimicry Guild 2010).](image-url)
This framework was presented to the authors with the Biomimicry Guild’s approach at a Biomimicry workshop in Eindhoven, Netherlands from 3-4 March 2010, and had a major contribution to the way the research was conceptualized and framed. The strategy of the suggested approach is to focus on finding nature’s best organismal examples and applying the principles behind their success to human design. To allow for true innovation and to avoid biased observations, the approach recommends looking at nature with open eyes and minds, while quieting one’s current knowledge of human design.

Despite differences between human and other species’ communications, it is possible that successful communication patterns in nature hold lessons that may help to improve human communication.

1.3 Strategic Sustainable Development

The overall aim of this study is to help move society towards global socio-ecological sustainability. In order to provide a strategic approach and a whole systems perspective, the Framework for Strategic Sustainable Development (FSSD) is presented (Figure 1.2). The FSSD was developed to help tackle today's sustainability challenges. It is a robust, scientific model for planning and decision-making in complex systems. This framework utilizes the following five levels: system, success, strategic guidelines, actions and tools (Robèrt 2000).
The FSSD is a powerful tool in the journey to transform society towards sustainability, functioning both as a compass and a road map. The first level of the FSSD enhances common understanding of the system’s boundaries and limitations. From individuals through organizations and society to the entire biosphere, all subsystems operate within the constraints of natural laws and have continuous impacts on both local and global scales (Figure 1.3).
Figure 1.3. Understanding the System’s Boundaries (as adapted from Robèrt and others 2007).

Using the FSSD requires a clear definition of success: achieving global socio-economic sustainability. The definition for success, provided by the four Sustainability Principles (Figure 1.4) is comprehensive, science-based and concrete; describing the conditions required for a sustainable society (Robèrt and others 2000).
Using these Sustainability Principles to help define a clear vision of success, the FSSD can be applied by organizations of different scales and sectors (private companies, non-governmental organizations (NGOs), municipalities, national and global organizations and individuals) in order to guide them through a stepwise approach, towards upstream, sustainable solutions. Using backcasting from success as defined by the Sustainability Principles as a leading strategy, the most suitable actions and tools can be selected and implemented, while each step is regarded as a stepping stone towards the next one.

Differentiating between backcasting from principles and backcasting from scenarios is important when understanding what makes the FSSD strategic. Backcasting from scenarios often demands reaching a consensus, which may be difficult to achieve especially when considering the complexity of sustainability challenges. Backcasting from scenarios may also lead to concentrating on specific solutions, rather than on the overarching vision these actions are meant to support.
Backcasting from the Sustainability Principles provides the opportunity to optimize strategic decision making that will move an organization, society or an individual towards sustainability. When backcasting from the Sustainability Principles, the overarching vision of global socio-ecological sustainability is shared, and allows creativity within their constraints. Based on strategic guidelines and the Sustainability Principles, different actions and measures can be selected in a step-wise approach that allows for opportunities to re-evaluate changing conditions and the chosen actions along the way. There can be more than one action or a combination of actions that can be used to achieve sustainability. In changing conditions, backcasting from principles would allow better ability to adjust the selected set of actions to ensure that the overall vision will be met.

To help backcast from Sustainability Principles a tool called the ABCD Process can be used. This tool involves four steps where “A” is awareness of the entire system and of the current reality of the sustainability challenges in today’s society. A common mental model or vision for success based on the Sustainability Principles is also shared with all stakeholders. The “B” step is a baseline assessment to understand both the positive and negative aspects of the system with regards to sustainability. The “C” step is creative solutions in which all possible solutions for moving closer to sustainability are listed; including solutions that are considered “low hanging fruit”. The final step is the “D” step where solutions from the “C” step are prioritized based on the three strategic guidelines, represented by the following questions:

- *Does this measure move the organization in the right direction?*
- *Does this measure provide a flexible platform to maneuver?*
- *Does this measure produce a sufficient return on investment* (Robèrt and others 2007)?

Using the ABCD Process helps to strategically guide organizations and individuals to have a shared mental model for success as defined by the four Sustainability Principles. Through the use of the ABCD tool within the FSSD, creative tension between the current reality and desired future is developed by choosing challenging goals and actions that are still realistic to achieve in a reasonable period of time. These become the stepping stones that lead organizations, societies and individuals on the path towards sustainability.
Inspiring organizations and individuals to adopt the FSSD can be challenging because messages around sustainability are often confusing, not effective enough to create action or are just not reaching the intended audience. Taking nature’s examples of successful communication patterns and using them to help communicate sustainability messages more effectively, could assist people in recognizing the importance of using a strategic framework such as the FSSD that will help them progress towards a more sustainable society.

1.4 Purpose and Scope

“Look! Look deep into nature and you will understand everything.”

(Albert Einstein)

The purpose of this research is to encourage sustainability practitioners and others who want to communicate sustainability, to look at nature for inspiration when designing and delivering sustainability messages. Furthermore, this research seeks new insights and recommendations regarding more effective ways to communicate sustainability messages, by emulating communication patterns that are used in nature.

This study realizes that effective communication is only one small part of creating sustainable behavior. Other factors may influence behavior, but due to the scope and timeframe of this paper, only research focusing on effective communication in nature will be used.

The scope of this paper does not include looking at existing communication theories in human society because the research methods used in this paper specify to first look at nature’s examples with the purpose of finding new lessons to be learned from nature. If existing communication theories in human society were incorporated into the research methods it had the potential to bias the authors with preconceived ideas of what works and what does not.

1.5 Research Question

How can communication patterns observed in nature help to effectively communicate sustainability messages?

Using the concept of Biomimicry, this study aims to:
• investigate case studies of observed communication in nature;
• identify common, underlying patterns of communication in nature;
• create nature inspired guidelines that can be used to successfully communicate messages about sustainability in human society, which could result in the needed behavior change towards sustainable living.
2 Methods

2.1 Research Design

2.1.1 Qualitative Research Design

An Interactive Model for Research Design presented by Maxwell (2005) was used to help clarify the purpose and goals of this study. The model presented a dynamic approach to qualitative research that allowed a multi-perspective approach in a non-linear process. A change in one field meant a change in another and resulted in an ongoing design process.

![Qualitative Research Design Diagram](image)

Figure 2.1. Qualitative Research Design (Maxwell 2005).

2.2 Research Methods

The overall process of the research consisted of six main stages (Figure 2.3). Though presented in a linear flow, the process itself was not linear. Repetition and some overlapping between the stages were seen, while new insights went back and forth reshaping and enriching the different stages.
Methods were also designed to include validation by experts and peers at the two feedback stages. Validation will be explained in the discussion.

**Figure 2.2. Research Methods Flow Chart.**

### 2.2.1 Stage One: Preliminary Literature Review, Information Gathering and Analysis

Using Maxwell’s model for qualitative research design, an initial conceptual map was created to help identify related fields of study, as well as to recognize gaps in the authors’ understanding of the topic. This helped to direct the preliminary literature review that included scientific peer-reviewed journals such as: *Nature, Proceedings from the National Academy of Sciences, Behavioral Ecology, Trends in Ecology and Evolution* and others. These journals were searched for a variety of articles relating to keyword searches that included: animal communication, consensus decision making, Biomimicry, signals, information, biosemiotics, swarm intelligence, psychology, plant-animal interactions, etc. Books, lectures, online videos, interviews with experts and case studies were also consulted to cover this interdisciplinary research that included fields from behavioral ecology to climate change psychology (see Appendix B). This preliminary literature review was essential in order to better understand the related issues, to help refine the research goals and research question and to determine the scope.

Overall, this preliminary literature review and the targeted literature review done later in the study involved the analysis of 80 peer-reviewed articles.
and nine textbooks that focused on animal communication and animal behavior.

All sources of information were continuously uploaded onto a website called Zotero (http://www.zotero.org/). Here notes, word tags, groupings and references were used in order to categorize and sort relevant information that was gathered throughout the research process.

2.2.2 Stage Two: Identification of Communication Patterns in Nature

Based on the six Life’s Principles (Figure 1.1) and the recommended research approach, the following steps were taken in order to identify communication patterns in nature:

1. Identified functions used in nature for creating and sending messages. These functions formed the base from which questions were designed to research in detail communication patterns that exist in nature. The functions were selected during a group brainstorming session with Biomimicry students and practitioners at the Biomimicry workshop in Eindhoven. The six selected functions are presented in the results section.

2. Designed questions based on the selected functions, e.g.: “how does nature (achieve this function) in a way that is consistent with (each of the Life’s Principles)?” For example, “how does nature attract attention in a way that is locally attuned?”; “how does nature exchange information in a way that is resilient?”; “how does nature direct behavior in a way that optimizes rather than maximizes?” etc. (Figure 2.3).

3. A second, targeted literature review of various strategies used by different organisms in nature was conducted based on the Biomimicry approach. This was similar to the preliminary literature review, except that the keywords searched focused on the previously selected functions, such as “decision making”, “exchange information” etc. Communication patterns that were repeated by three or more different organisms were identified.

4. Identified communication strategies used in nature were then developed into 14 underlying patterns that were called “Underlying Patterns of Communication in Nature” (Underlying Patterns).
The analysis of information was organized using a Microsoft Excel spreadsheet that contained the six Biomimicry Guild’s Life’s Principles and the six selected functions for effective communication.

<table>
<thead>
<tr>
<th>Life’s Principles</th>
<th>Functions</th>
<th>Attract Attention</th>
<th>Exchange Information</th>
<th>Direct Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locally Attuned</td>
<td></td>
<td></td>
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*Figure 2.3. Identification of Communication Patterns in Nature.*

### 2.2.3 Stage Three: Feedback on Underlying Patterns

Initially 20 emails were sent out to experts in these fields requesting feedback. Only seven responded. The Underlying Patterns for Communication in Nature were sent to three experts in the field of Biomimicry, to two in the fields of animal communication and animal behavior and to two in the field of biology for feedback. This stage was meant to ensure the Biomimicry framework and suggested approach were used correctly and that the communication patterns identified in nature were used properly. The reviewers were asked the following questions:

- Was the Biomimicry framework and suggested approach used correctly (for Biomimicry experts only)?
- Based on your experience, are these Underlying Patterns correct in the way they have been phrased?
Have you seen these patterns in your own research?

Can you think of other patterns for communication that are missing?

Is the wording clear?

The gathered feedback was reviewed, discussed and relevant comments were integrated to both validate and refine the Underlying Patterns.

2.2.4 Stage Four: Development of Guidelines for Effective Communication of Sustainability Messages

Based on the identified patterns from nature, the Guidelines for Effective Communication of Sustainability Messages were created. These Guidelines were designed by translating the Underlying Patterns into a user-friendly language that was easy for any communicator of sustainability to understand. These Guidelines were designed by using descriptions of the communication pattern in nature and by exemplifying possible applications of them in human society. The development of the Guidelines included many iterations of design and feedback, mostly around their wording and presentation. A graphic mapping session with a professional facilitator helped to solidify the Guidelines by identifying each of the Guideline’s keyword(s). This was helpful to clarify each Guideline’s unique contribution as well as their interconnectivity. This session also influenced the order in which they are presented. A mind map was also created to help illustrate the interconnections between the Guidelines (Appendix C).

2.2.5 Stage Five: Feedback on Guidelines for Effective Communication of Sustainability Messages

The Guidelines were sent to 12 experts in the field of Sustainability who practice communicating sustainability messages either through workshops, campaigns and/or interpersonal communication with different individuals and organizations from various sectors. Six of them replied. The Guidelines were also given to ten peers from five different countries in the Master’s programme for Strategic Leadership towards Sustainability (MSLS) 2010 class. Their diverse experience, multicultural background and intensive training around Strategic Sustainable Development allowed them to provide critical feedback. Three of the ten peers were asked the same questions as
the sustainability experts because their research involved communication strategies for sustainability messages.

The experts and three peers were asked the following questions:

- Are the Underlying Patterns and Guidelines clearly worded? Do you understand what we are saying?
- Do you find these Guidelines useful in your work? If so, in which situations would you use them? If not, why?
- Do these Guidelines inspire you to look at nature to find more creative ways of communicating your messages?
- In some of the Guidelines, we have offered general suggestions as to how you might use the Guideline. In others, we did not present this type of information. Does offering some suggestions help you to be more creative? Or do you think it might hinder your own ideas?
- What type of additional information might make the Guidelines more useful and inspiring for you?
- The reviewers were encouraged to add any other comments or suggestions based on their own experience.

The remaining seven peers were asked if the Guidelines made sense as written and how their wording could be improved. In addition, the Guidelines were sent to an expert in the field of communication and marketing in order to receive feedback concerning their clarity and attractiveness.

2.2.6 Stage Six: Feedback Integration and Compilation of Guidelines

All the comments and suggestions from feedback were gathered into a table and categorized by the questions asked and the relevancy of the answers. Each comment was discussed to determine whether to incorporate them into the final version of the Guidelines and in what ways.

The Guidelines were then modified to incorporate suggestions and comments made by the reviewers. “Stories from nature” were added to help
explain the origin of the guideline and inspire creativity, as well as a checklist of questions to help exemplify practical applications in different sustainability settings as suggestions for users. To appeal to different learning styles, images and graphics were created.
3 Results

The results presented below incorporate the relevant feedback received from experts and peers for both the Underlying Patterns and Guidelines.

3.1 Underlying Patterns of Communication in Nature

To derive the Underlying Patterns of Communication in Nature, the authors identified six functions for effective communication at a Biomimicry workshop in Eindhoven, Netherlands:

- attract attention (AA)
- information exchange (IE)
- direct behavior (DB)
- incentivize behavior (IB)
- maintain behavior (MB)
- decision making (DM)

These functions were used with the Biomimicry approach to identify the 14 Underlying Patterns of Communication in Nature. By asking questions using the six functions and six Life’s Principles such as “how does nature attract attention in a way that is locally attuned”, organisms from nature were found that use a locally attuned strategy to attract the attention of their audience. When at least three organisms in nature showed a particular overlapping strategy for each question, the strategy was developed into a pattern. For example, sheep, a yellow chinned anole and bees all use their bodies to attract attention in a way that is locally attuned by sending the same message more than once. The sheep repeatedly stamp their feet, the yellow chinned anole does push-ups numerous times and the bee “waggles” many times when attracting the attention of others. The identified pattern in this case was “send the same message more than once”. The Biomimicry Guild’s approach seeks these types of underlying patterns used in strategies by various organisms.

Once patterns were developed, each of them was introduced by the phrase “When communicating nature will…” followed by the pattern itself; three example organisms from nature, the Biomimicry Guild’s Life’s Principles
When communicating nature will...

... Send the same message more than once.

Examples in nature:

- Sheep in decision making for group repeat step and head movements to spread message (Ramsey and others 2009).
- Yellow chinned anole uses push-ups to repeatedly attract attention (Ord and Stamps 2008).
- Waggle dance of bees - scouts repeat the same dance many times (Wenner and others 1967).

... Send the same message using more than one method and/or multiple signaling.

Examples in nature:

- Wolf scat is used as visual and chemical signals to communicate territory (Barja 2009).
- Male riflebirds use visual display with explosive sounds, auditory and visual signals to attract female in courtship (Rogers and Kaplan 2002).
- Gorillas use various visual, tactile and auditory signals. The signal used to convey a message will be adjusted based on the behavior (eye gaze, body or head position) of the interacting audience (Forrester 2008)

... Match the signal to receiver and desired actions.

Examples in nature:

- Thomson's gazelle: stotting directed at the predator signals physical fitness and ability to escape. This signals to predators that it would be a waste of their energy to attack (Rogers and Kaplan 2002).
- A sheep orients itself in the direction it wants the group to go (Ramsey and others 2009).
- A mother plover draws a predator away from her nestlings by visual signals, pretending to have a broken wing (Rogers and Kaplan 2002).
- Moth and butterfly eyespots ("ocelli"); when birds attack the moth, its wings open to reveal ocelli and predator peck at the ocelli instead of body (Rogers and Kaplan 2002).

... *Consistently use the same message in a certain context.*

Example in nature:

- Vervet monkeys use three different signals for three different threats to be able to respond to them differently (Scott 2005).
- Elephants sound the same alarm calls in response to the sound of disturbed African honeybees (King and others 2010).
- Chimpanzee barks used when hunting are short whereas the barks used in the presence of a snake are long and in one tone (Crockford 2003, 121).
- Cambell’s monkeys use a specific call type for: cohesion and travel, falling trees, neighboring groups, non-predatory animals, unspecific predatory threat, and specific predator classes (Ouattara and others 2009).

... *Adjust the signal to environmental conditions.*

Examples in nature:

- Humpback whale: change the song pitch with temperature; higher pitch travels better in cold water (Scott, 2005).
- Cassowary birds in Papua New Guinea produce booming sounds at very low frequencies which are ideal for communication among widely dispersed, solitary cassowaries in dense rainforests (Andrew and Jones 2003).
- The nocturnal Eagle owl increases the frequency of its calls on nights with a full moon as the visibility of their white feathers increases (Penteriani and others 2010).

... *Design a signal that is appropriate to the timing of the receiver.*

Examples in nature:

- Wolves use chemical and visual signals in scat for continuous message (Barja 2009).
The change in color of a fruit signals it’s ripening to the animals that would help scatter its seeds. The timing of the color change has to suit the right weather, presence of animals and readiness of seeds. (Stiles 1978).

Bacteria called *Vibrio fischeri* produce a bioluminescent protein that creates the light under the eyes of some fish species. The bacteria only turn on the light after reaching a certain amount of cells in the colony (TED 2009).

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**Create short feedback loops.**

Examples in nature:

- Argentine ant *Linepithema humile* secret pheromones when making trails to where resources are located. Several trails may be made, but ants choose the trail where more pheromones have been laid and add to it to create a positive feedback loop, so that only one trail is used (Fewell 2003).

- T cells in the immune system are dependent on feedback loops for sensing their surroundings and processing incoming signals (Bischofs and others 2009).

- Harvester ants' decision making about which tasks to perform and whether they should perform them now depends on interactions with other worker ants (Gordon 1996).

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**Utilize close relationships and promote mutualistic interactions.**

Examples in nature:

- Monkeys will respond to an alarm call from a trusted and known source coming from a member of the group or a neighboring species (Scott 2005).

- When recruiting other sheep, individual sheep are more effective using affinitive relationships to help pass on messages (Ramsey and others 2009).

- When foraging in mixed groups one bird can send an alarm and other species of birds will fly away (Scott 2005).

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**Be resourceful and use what is available**

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Examples in nature:

- Wolves use existing plants with specific physical characteristics: evaporation surface of plant for spreading; height of plant for optimal visual (Barja 2009).
- Different bird species that forage in mixed groups use each other’s signals (Scott 2005).
- To communicate their fitness and attract females, the Paradise birds of Papua New Guinea use colorful displays of their bodies. (Scholes 2008).
- Water striders use the surface tension of water to stand on it and send out vibrations that travel along the surface. The legs are also used as antennas, as each leg has nerve sensors that can detect slight waves (Forsyth 1992, 44).

... Create a message using simple components in different combinations.

Examples in nature:

- Bees use a waggle dance which is made up of three simple movements in order to communicate locations of various food sources (Wenner and others 1967).
- Butterflies use chemical communication consisting of simple compounds that are arranged in different orders to create multiple pheromones (Morse and Meighen 1986).
- The males of Free-tailed bats use a few basic phrases (a ‘buzz’, a ‘trill’ and a ‘chirp’) in different combinations to create a variety of different songs (Bohn and others 2009).
- Chimpanzees combine barks, drums and other types of calls to increase the signal specificity (Crockford 2003, 120).

... Consider proximity/spatial distance when sending a message.

Example in nature:

- Sheep recruitment more successful when the distance in between sheep is small (Ramsey and others 2009).
- The yellow chinned anole uses push-up movements to attract the attention of its receiver when it is far away (Ord and Stamps 2008).
Gorillas will determine which signal to use depending on the proximity of the receiver (Forrester 2008).

Use methods that do not create unusable waste.

Example in nature:

- All examples shown in the patterns are not creating unusable waste (e.g. Wolf scat used as a communication signal for marking territory becomes food for other organisms).

Conserve energy / optimize energy use

Example in nature:

- The yellow chinned anole attracts the attention of receiver before sending a message (Ord and Stamps 2008).
- Change in fruit color only occurs when the seeds are ready to be scattered and the fruit is ready to be eaten (Stiles 1978).
- A sheep orients itself in the direction it wants the group to go (Ramsey and others 2009).

Spread messages using decentralized and distributed information.

Examples in nature:

- Bees' scouts distribute information about hive sites (Conradt and Roper 2005).
- Neurons in human brains are not controlled by any “central command”. All decision making processes are a result of decentralized and distributed communication (Laughlin and Sejnowski 2003).
- Ants pass information to other ants mainly using pheromones, and each ant makes its decision independently based on the local information it has available (Kostoulas and others 2007).
3.2 Guidelines for Effective Communication of Sustainability Messages

Fourteen Guidelines for Effective Communication of Sustainability Messages were created by translating the Underlying Patterns into user-friendly language. Keywords from each of these Guidelines were extracted to help simplify these Guidelines quickly for any user. To help strengthen the understanding of these guidelines they were formatted with:

- The keyword
- The Underlying Pattern
- A story from nature to illustrate the pattern
- The Guideline
- A checklist of questions for guidance on how to use the Guideline

Subsequently they were arranged in an order that was felt to most appropriately help a sustainability practitioner design a message. It is important to note that although the Guidelines are presented in the form of a list for the purpose of this paper, *it is not recommended that they be used in any particular order*. All 14 Guidelines are listed on the following pages.
1: Audience. Desired Actions.

When communicating, nature will match the signal to the receiver and the desired actions.

When a predator is approaching her nest, a mother plover attempts to direct its attention away from her nestlings. She will do that by pretending to have a broken wing, sending visual signals of movements and body gestures while moving away from the nest. The predator, seeking an easy prey, will get the plover’s message: “I cannot fly!” and will often follow her, away from the nest (Rogers and Kaplan 2002).

When a Thompson’s gazelle realizes it is spotted by a predator, it will try to prevent him from attacking. Instead of running away, the gazelle starts jumping up and down in the same place (“stotting”), telling the predator: “I am fit enough to outrun you, better save your energy for a weaker prey” (Rogers and Kaplan 2002).

When designing your sustainability message…

Understand your target audience and what you want them to do.

Ask yourself:

- What background information about my audience would be helpful?
- What do I know about the audience’s cultural, political, social and financial background? Do I understand their views?
- What is important to my audience? What is not important?
- What do I want them to do? Am I saying it clearly?
2: Context / Environment.

*When communicating, nature will adjust the signal to environmental conditions.*

In the vast ocean, temperatures can vary with depth and season. When swimming along in the ocean, Humpback whales adjust their song pitch when water temperatures change. In cold water their pitch is higher since higher pitches travel better in lower temperatures. In warm water the whales lower their pitch for better signaling. This immediate adjustment ensures that their message will be heard even when their fellow Humpback whales are miles away (Scott 2005).

*When designing your sustainability message…*

*Adjust the message and the way it is sent based on environmental conditions.*

**Ask yourself:**

- What are the conditions that may affect my message?
- What is the social, political, cultural atmosphere?
- What is the setting in which I will deliver my message (workshop? rally? lecture?)
- What in this setting can help or hinder my message?
3: Proximity.

When communicating, nature will consider proximity and/or spatial distance when sending a message.

As social animals, sheep rely on one another very heavily and have a lot of influence on each other. In some cases, this influence is strengthened by how close they happen to be standing next to one another when they are communicating. If one sheep decides it wants to move, this sheep is much more successful in its goal to get the entire flock to move if the individuals are standing close to each other. The message spreads much more quickly in this case (Ramsey 2009).

The yellow chinned lizard in Puerto Rico uses many ways to communicate and often chooses the best method depending on the distance of its audience. Push-ups are often the chosen means of alert when its neighbor is far away (Ord and Stamps 2008).

When designing your sustainability message…

Consider proximity when sending your message.

Ask yourself:

- Would this message be effective if sent via email? Perhaps personal communication is important in this case?
- For personal communication - what is the cultural comfort level of my audience considering personal space?
4: Timing.

*When communicating, nature will design a signal that is appropriate to the timing of the receiver.*

Many plants use animals to help scatter their seeds and grow edible fruits to attract and reward their service. When the time is right, meaning; when the seeds are ready, the weather is suitable and the animal-helpers are available, the fruit ripens and changes its color to signal to the animals “I am ready to be eaten”. If the color changes too early or too late, the chances for seeds to be scattered and to sprout successfully decrease (Stiles 1987).

In order to mark their territory, wolves use their own scat to leave their personal “signature” and keep competitors away (almost like a “keep out” sign). The scat can remain in its place for a few weeks allowing the wolf to save energy by not having to repeat the message again and again during this time. This example shows another aspect of timing in nature: not only the moment in which the message is sent is important, but also that the message is designed to last as long as it is needed (Barja 2009).

*When designing your sustainability message…*

*Make sure the timing of your message is appropriate.*

Ask yourself:

- When is my audience most receptive to the message?
- When will the audience be able to best apply the message and translate it into the desired action?
- How long is the message needed for?
- How long would the message be effective?
- Is there a way to make the message last longer?
5: Networks. Win-Win.

*When communicating, nature will utilize close relationships and promote mutualistic interactions.*

When a sheep decides to change its location, it would prefer to do so with the rest of the flock and therefore would first try to convince the other sheep to join it. When the sheep starts by first communicating to other sheep that are near it, the message spreads faster and more successfully. The initiating sheep starts by repeating a series of steps and head movements that gradually spread among the flock until enough sheep in the group are alerted and ready to go (Ramsey 2009).

*When designing your sustainability message…*

*Use your networks and make interactions rewarding.*

Ask yourself:

- Looking at your target audience: what networks can help spread your message to your target audience?

- How can your audience benefit from your communication and/or conversation?

- What is my audience getting out of it?

- How can I make the interaction rewarding for all parties?
6: Decentralized.

When communicating, nature will spread messages using decentralized and distributed information.

Amazingly organized, a community of bees can be directed to a new hive when only five percent of its members know the new location. “Scout” bees are the only members who know which direction the swarm needs to travel to arrive at the new hive and this information is passed to 10,000 bees who do not have this knowledge. This important information is not passed through a hierarchy, but through a selected and trusted group of members (the scouts) that create a more effective and efficient line of communication. It shows that information does not always need to go through a direct line of command and many times one scout only needs a few others to spread a message (Conradt and Roper 2005).

When designing your sustainability message…

Keep it local and spread it out to more than one source.

Ask yourself:

- Who can help you spread your message?
- Who are the “scouts” in your target audience – the people who will spread the information quickly and accurately?
- In a workshop, have I given people the opportunity to talk and cross-pollinate ideas?
7: Feedback.

When communicating, nature will create short feedback loops.

Some plants are dependent on ants to disperse their seeds and grow edible parts to attract them and reward their service. The ants that answer the plant’s call are immediately rewarded with nutritious food, which they carry to their nest for storage. The immediate feedback the ant is receiving ensures the ongoing relationship between the plants and the ants (Rico-Gray and Oliveira 2007).

When designing your sustainability message…

Create an interactive exchange of information within short time periods.

Ask yourself:

- How will I know if my audience received and/or understood the message?

- Can I design the message in a way that will ensure interactions with my audience?

- Is it a monologue (one way communication) or a dialogue (interactive)?

- How long should I wait before next interaction? When will it be too late?
8: Simplicity in combinations.

*When communicating, nature will create a message using simple components in different combinations.*

In a beehive, a special group of bees called “scouts” are assigned to go out to discover food sources and report their location to the colony. In a way, they function as the eyes of the colony. When a scout finds an interesting source of food, it flies back to the hive and communicates the location with great accuracy even if it is sometimes miles away. To do this, the scout bees communicate through a dance, called a waggle dance. The waggle dance is built from a full body vibration, a turn and a walk, in which each part is repeated over and over again. The length of the body vibration and walk as well as the angle of the turn can change to symbolize different locations. In this way the bees are able to create numerous different messages using a very limited number of simple basic elements (Wenner and others 1967).

*When designing your sustainability message…*

*Remember that messages can be created using simple components in different combinations.*

Ask yourself:

- Do I really need to reinvent the wheel, or can I use previous experience?
- Can I utilize other “known truths” the audience may already know to deliver my message?
- Is the message simple?
9: Resourcefulness.

When communicating, nature will be resourceful and use what is available.

Most animals make the most out of what they have in order to communicate. Some use objects available in their surroundings. Male bowerbirds collect colorful petals, insects and stones and then organize them neatly into separate piles to decorate amazing nests they build out of sticks and leaves found in the forest. The impressive nests attract females and show the males’ competence as mates (Diamond 1986).

Most animals and plants use their own body in order to communicate by using movements, gestures, colors, sounds, scents etc. A clear example can be seen in many plants that rely on insects for pollination; the bright colors of the flowers, their scents and structures are designed to especially stand out in fields to attract the insects (Ragusa 2004). This pattern is also evident with use of the tail of the male peacock as the message. This attracts females to its bright beautiful colors and because the tail is a burden on the peacock, it also communicates to the female that the male is healthy and in great shape (since it can grow and carry such a heavy tail and still avoid predators) (Zahavi 1997).

When designing your sustainability message...

Be resourceful and use your skills, tools and existing materials.

Ask yourself:

- What do I have?
- Do I really need to produce new things?
- Is there a way in which I can BE the message?
- What do my appearance and behavior communicate to the audience without words? How can I utilize it to strengthen the message?
In nature, waste equals food. This is to say that although many animals do create waste, this waste is actually useful and necessary to other organisms or to the ecosystem. Birds often use “waste” from plants and trees as construction materials for their nests. Wolves are known for protecting their territory and mark this territory using their scat. This “waste” communicates their message both visually and chemically (Barja 2009). This communication method (the scat) does not pollute their environment, as it eventually becomes food for the ecosystem.

When designing your sustainability message…

Be innovative and find ways in which waste equals food!

Ask yourself:

- If I use materials to deliver my message, what happens to them after the message is received?
- Are they reusable? Recyclable?
- Have I ensured they will be reused or recycled?
- Not all waste is tangible. Is the message important and useful for my audience?
When communicating, nature will conserve energy and/or optimize energy use.

In the natural world, as well as our world, it can be very difficult to get messages through when there are other competing messages. The yellow chinned lizard in Puerto Rico is known to first attract the attention of its audience doing repetitive push-ups (visual display) before communicating the “real” message. Once the lizard has succeeded in getting the attention of the receiver it will then pass along the important and energy intensive message. In this case, it is not wasting time or energy to send a message that the other lizards would not get (Ord and Stamps 2008).

When designing your sustainability message…

Optimize energy use.

Ask yourself:

- Would my message make the most impact if sent now? Is my audience receptive to it now or is it better to wait (see also Guideline five)?

- Assuming there are several options to designing my message, which one is making the best use of my energy, my audience and which is the most energy efficient?
12: Repetition.

When communicating, nature will *send the same message more than once.*

In a busy beehive, full of noisy bees, complex messages are communicated using a combination of three simple movements in a dance called the “waggle”. It is used to communicate information containing locations of food sources or new potential hives. The waggle dance is built from a full body vibration, a turn and a walk, in which each part is repeated over and over again (Wenner and others 1967).

*When designing your sustainability message…*

*Repeat the message.*

Ask yourself:

- Have I repeated my message? When? How many times?
- What is the best way to repeat my message (see also Guidelines 13 and 14)?
13: Variation.

When communicating, nature will send the same message using more than one method and/or multiple signalling.

A male Paradise bird has brightly colored feathers in contrast to his female counterpart. When the male wants to attract the female to mate, it uses those brightly colored feathers to perform a lively dance for the female. Showing off the blue feathers on its rump, dancing by hopping in front of the female and performing loud, vocal songs are all different methods of sending the same message, “hey let’s mate” (Rogers and Kaplan 2002).

When designing your sustainability message…

Vary the way you send the message.

Ask yourself:

- Is there another way in which I can explain or spread the message?
- Have I tried:
  - Using different colors?
  - Incorporating stories and poems?
  - Calling?
  - Using social networks?
  - Appealing to different learning styles?
  - Appealing to more than one sense?
14: Consistency.

When communicating, nature will consistently use the same message in the same context.

The beautiful African elephants sound a specific alarm call in response to a disturbed swarm of bees. Despite having almost no natural enemies in the savannah, the big animals consistently sound and respond to this alarm call (King and others 2010).

When designing your sustainability message…

Consistently use the same message in the same situation.

Ask yourself:

- Am I being consistent with the terminology I am using?
- Before resending a message, have the conditions changed?
- Do I really need a new slogan/logo/story?
4 Discussion

4.1 Experts’ Validation

This study aimed to find innovative methods for improving human communication of sustainability messages using the Biomimicry framework and approach. Guidance and support received from the Biomimicry Institute as well as a workshop attended by the authors to practice the approach strengthened the validity of the research design and methods.

However, time became a limiting factor in this study with regard to the number of organisms that were researched. The Biomimicry Institute suggested a literature review of 200 organisms, but due to time only 35 organisms were found with research relating specifically to communication patterns. This resulted in a small sample size of organisms that were used to identify the Underlying Patterns. If more organisms had been used, possibly more patterns in nature could have been found. Time also limited the authors from testing the Guidelines on specific target audiences.

Another challenge was limited access to experts in the fields of Biomimicry, animal communication, animal behavior and biology. Only seven experts in these fields responded to the authors’ requests for feedback. For the Guidelines, six sustainability experts and ten MSLS peers from five different countries provided feedback. A larger number of reviewers would have helped to solidify the Guidelines even more.

The Underlying Patterns and the Guidelines were all based on organisms’ strategies that were selected according to the six functions of communication identified by the authors. Different functions may have resulted in the selection of different organisms’ strategies and perhaps led to different results.

Finally, the authors were aware of the unavoidable subjectivity involved in the qualitative analysis of organisms in nature. To reduce bias and avoid anthropomorphism (projection of human traits and properties to non-human species) the authors did not analyze human communication methods.
4.1.1 Feedback on Underlying Patterns of Communication in Nature

The 14 Underlying Patterns of Communication in Nature were sent to three Biomimicry experts, two experts in animal communication and animal behavior and two experts in biology for feedback. The most relevant responses to the questions asked are shown below:

*Was the Biomimicry approach used correctly (for Biomimicry experts only)?*

- Two out of three said yes; the third had no response.
- One expert commented that one overarching function of “communication” could have been used instead of six functions although these six would be subfunctions. However using them as is was still valid.
- One expert commented that it was better if the authors looked more broadly at nature, instead of trying to fit examples into functions.

*Based on your experience, are these Underlying Patterns correct in the way they have been phrased?*

- Four out of seven said they were correct in the way they had been phrased. Three had suggestions for how they could be phrased differently.

*Have you seen these patterns in your own research?*

- No responses were given for this question, but one expert noted that evolution needed to be discussed.

*Can you think of other patterns for communication that are missing?*

- Four out of seven suggested examples of ecosystems, group work and certain situations such as urgency for further research. Three had no response.

*Is the wording clear?*

- Seven out of seven said yes, the wording was clear.
Overall the majority of feedback was on the examples. Experts pointed out which examples were unclear or if an example could be used with other patterns. Most however, commented that there are other organisms in nature that could have been observed in the literature review.

4.1.2 Feedback on Guidelines for Effective Communication of Sustainability Messages

The Guidelines for Effective Communication of Sustainability Messages were sent to 12 sustainability practitioners, six of whom replied. The Guidelines were also sent to ten peers in the MSLS 2010 class. Three of these peers and all sustainability practitioners were asked the following questions. The remaining seven peers were asked if the Guidelines wording made sense and was clear. The most relevant responses to the questions asked are shown below:

Are the Underlying Patterns and Guidelines clearly worded? Do you understand what we are saying?

- Two out of six experts and three out of three peers said they were clear and they understood. Three experts had no response and one expert said some were clear and others were not.

Do you find these Guidelines useful in your work? If so, in which situations would you use them? If not, why?

- Five out of six experts and three out of three peers said they would be useful in planning a workshop, designing a sustainability message or as a tool for teaching sustainability related communications. One expert did not respond.

Do these Guidelines inspire you to look at nature to find more creative ways of communicating your messages?

- One out of six experts and three out of three peers responded: “yes”, while one expert said they would rather look to human settings for inspiration. Four experts did not respond.

In some of the Guidelines, we have offered general suggestions as to how you might use the Guideline. In others, we did not present this type of
information. Does offering some suggestions help you to be more creative? Or do you think it might hinder your own ideas?

- One out of six experts and three out of three peers found the suggestions to be helpful, but one expert pointed out they could be limiting and advised to ask the reader to reflect on their own experiences first. Four experts did not respond.

What type of additional information might make the Guidelines more useful and inspiring for you?

- Five out of six experts and three out of three peers said visuals, a shorter list and more examples of organisms. One expert did not respond.

The reviewers were also encouraged to add any other comments or suggestions based on their own experience. The main response was to make the wording clearer and to incorporate using the Guidelines to specifically communicate the FSSD.

The remaining seven peers were asked whether the wording of the Guidelines were clear and made sense. Based on the Guideline, answers varied from “yes they made sense” to them making wording suggestions to help clarify the Guidelines.

The Guidelines were also sent to one marketing expert to ensure that the language of these guidelines was clear and user-friendly. The response received from this expert showed that the authors were on target with the language used.

Also, based on the feedback a mind map was created to show the interconnections between the Guidelines (see Appendix C). This was one way to view the Guidelines and their interactions. Other ways to use them synergistically could be created according to the specific needs of the user.

Overall feedback showed that communication patterns observed in nature could be used to improve communication of sustainability messages. This could be done through using the Guidelines as a checklist and a design tool when designing sustainability messages and methods for communicating the message. Further research would be needed to test these Guidelines and determine if they were effective for specific target audiences.
4.2 Expected Results versus Actual Results

The authors were confident that successful patterns in nature for communication existed. Although it was not known at the beginning what shape these patterns would take or how they would compare to human patterns, it was assumed that there is much to learn from nature. Initially this was known not by doing research, but from individual observations that resulted in questions when observing nature:

“How do trees change the leaves’ colors in almost complete synchronicity when the time comes?”

“How does a wolf pack bring down their prey in a seemingly choreographed way without appearing to be communicating at all?”

“How do fish swim in a school without swimming into each other?”

As deeper insight developed through the use of Biomimicry and the literature review, many new learning opportunities emerged. New ideas in the form of specific examples about how organisms often use multi-functional designs or effectively communicate a message in various environments were a source of motivation and enthusiasm throughout the research project. Due to the short time period given for this study, the full potential of what can be learned from nature when communicating messages is yet to be discovered.

Should time have allowed, further research would have been done allowing more examples to be incorporated into the Underlying Patterns. This would have made the results stronger. However, by verifying the Underlying Patterns with animal communication experts, animal behavior experts and Biomimicry experts, the results were considered valid and applicable.

One surprising aspect of the results was that many of the Underlying Patterns in nature are used in human society as well, including in sustainability campaigns. For instance, an organization may attempt to communicate a message about climate change using a campaign that includes emails, informative articles in the newspaper and through films, as is also recommended by the Guidelines: “send the same message more than once” and “vary the way you send your message”. People receive the
message, but the process of communicating often does not result in the needed long lasting behavior change. The reasons for this as well as the role that communication plays in behavior change are beyond the scope of this particular study.

Discerning the unique contribution the Guidelines can bring to communication in human society, as well as formatting them in a way that they are clearly distinct from what humans are already doing became a challenge. To help address this, the Guidelines were sent to sustainability practitioners for feedback. The feedback was used to make adjustments in order to create inspiring Guidelines that would help people effectively communicate sustainability messages.

With the understanding that the Guidelines still demand further work in order to make them easier and more useful for sustainability practitioners, the format of the existing Guidelines is still useful and offers value for communicating sustainability. They can be used as a foundation for designing new and innovative messaging systems that are inspired by nature. Several insights about the Guidelines and their recommended applications are discussed in the next sections.

4.3 Nature Inspired Communication for Human Society

One very important point that is necessary to reiterate is that the methodology used in this research paper focused on learning from patterns and strategies used in nature. At times both the official and the informal feedback given with regard to the Guidelines and the topic in general brought up concerns that the paper was doing literal comparisons of humans to other organisms. This paper was not suggesting that organisms in nature share the same cognitive levels as humans or that humans should literally ‘waggle’ like a bee. The research of the paper focused on strategies used in nature that can inspire innovative designs of messaging methods in human society.

4.3.1 Differences and Similarities in Communication Methods

When applying the Biomimicry discipline to social issues such as human communication, recognizing both the basic differences and similarities
between other species’ and human communication can be meaningful. As Biomimicry is sometimes described as “a remembering process” (Baumeister 2010), recognizing the gaps and bridges between humans and other species can provide insights into what society has forgotten or perhaps has not yet learned that could be useful to help communicate sustainability issues more effectively.

Human communication stands out as relying heavily on symbolic signs, such as written and spoken language. Words are symbolic because they are arbitrary and/or conventional; they have to be agreed upon and learned in order to have meaning (Chandler 2007) (Figure 4.1). Only a few other species are known to use symbolic signs (Hoffmeyer 2010), but current research is still limited and arguable.

![Figure 4.1. Words as an Example of Symbolic Communication.](image)

Another fundamental difference is the impact the industrial and technological revolutions have had on human communication methods. As a result new methods and forms of communication have been developing at a rapid pace. Therefore, any communication strategy developed today must be updated and adjusted to the rapidly changing technology and communication habits that follow it. This is currently a challenge that communication strategies need to address.

Finally, two important differences between humans’ and other organisms’ communication are energy considerations and environmental implications. While other organisms use methods that optimize energy and resource consumption that were developed over the course of evolution (Johnstone 1997; Bradbury and Vehrencamp 1998), it seems that people are much less careful and not as aware of these issues when designing their
communication strategies. One possible cause for this could be the technology that has allowed humans to utilize external sources of energy rather than just relying on their own body. This may sometimes lead to viewing the energy sources as everlasting and/or disconnected from society, which could be one cause for the current sustainability challenges.

Despite these differences, humans are a part of nature and share similarities with the rest of the natural world. Both humans and other species have the ability to sense and communicate with their surroundings through their sensorial systems (Czeschlik 1998). The physical structure that enables them to transmit, receive and interpret information has a significant influence on their communication characteristics (Johnstone 1997; Bradbury and Vehrencamp 1998). Other key factors in shaping communication are their surroundings and needs (Johnstone 1997; Bradbury and Vehrencamp 1998). Although many species-specific communication methods are inaccessible to humans (e.g. UV perception in bees, echolocation in bats and dolphins, etc.), matching the signal to the physical ability of the intended receiver to receive and interpret it is a required condition (Czeschlik 1998; Endler 1993). Also, communication is almost always context dependent (Maran 2010). In other words a signal, whether a specific word in human language or a call given by a bird, could have different meanings in different situations.

4.3.2 Insights

It was suggested many times as feedback that the Guidelines for Effective Communication of Sustainability Messages should be combined and consolidated for easier reading and use. Comparing the Guidelines to communication theories used in society was also suggested a few times. In spite of the time constraints an attempt to consolidate the Guidelines was done with the assistance of a facilitator with familiarity of a few current communication theories.

From this session, it was determined that the Guidelines could not be consolidated without losing their value. Further discussions have helped solidify the following insights about the Guidelines and the recommended way to apply them:

- Although some Guidelines appear similar, each is distinct. “Repeat the message” is not the same as “Vary the message”. Varying the
way a message is sent is one strategy that can be used for repeating the message.

- In many cases a Guideline may become a strategy for using a different Guideline. To “optimize energy use”, one might choose to make “the timing of the message appropriate” by only sending a message when the audience is certain to receive it. This avoids wasting time and energy of sending a message that could potentially never be seen or heard.

- The Guidelines are multi-dimensional; meaning they are interconnected and work synergistically with each other. As demonstrated in the previous two points, the Guidelines are often overlapping and are valuable in different contexts. They are most effective when looked at as multidimensional rather than as linear. For one suggestion of using the Guidelines synergistically, see Appendix C.

- The Guidelines are a starting point or a checklist when designing or sending a sustainability message. They are not intended to be a set solution or a ready-to-use formula. The Guidelines could help sustainability communicators to best tailor the message to each situation, thus increasing its effectiveness.

- Apart from the benefit of communicating effectively with the help of the Guidelines as a tool, the Guidelines can help move society towards sustainability by enhancing systems thinking. The mere idea of learning from nature is an appreciative and humbling approach that the authors believe is essential to promote the global transition towards socio-ecological sustainability.

Future research is needed to strengthen the idea that the approach used in nature is multidimensional and that communication strategies often used in human society are using a linear approach by trying to fit strategies into preconceived categories.
4.4 The Framework for Strategic Sustainable Development (FSSD) and Biomimicry

Although one of its main goals is to promote sustainable solutions to human challenges, the Biomimicry discipline does not entail a clear definition for sustainability.

The discipline does state that in order for humans to survive as a species on this planet, it is essential that we learn to create conditions conducive to life, as all well adapted organisms have done (Biomimicry Institute 2010). According to the Biomimicry discipline, this may be reached with the help of Biomimicry only if it will be applied constantly in all three possible levels: mimicking natural forms, processes and systems (Biomimicry Guild 2010).

One example for mimicking natural forms is studying the spider’s web chemical structure to produce fine yet extremely resilient fibers (Gould 2002). Mimicking natural processes could include emulating the process in which the spider creates the fibers using natural, degradable materials only, without involving polluting and high energy cost manufacturing as humans do (Gould 2002). Finally, the level of natural systems refers to the way in which the web is part of the spider, which is in turn part of its habitat in the biosphere. All of these subsystems are connected and maintain dynamic and sustainable relationships.

“If you make bio-inspired fabric using green chemistry but you have workers weaving it in a sweatshop, loading it onto pollution spewing trucks and shipping it long distances, you’ve missed the point.”

(Janine Benyus)

It is important to understand that following the Biomimicry Guild’s Life’s Principles framework does not fully ensure a sustainable outcome as defined by the Sustainability Principles. The most obvious gap is in relation to human needs; as the Life Principle’s were derived from nature’s patterns, there is no separate reference to human society’s needs. Therefore, as noted
by Benyus above, products and processes that were designed according to the Life’s Principles may still prevent people from meeting their needs and contribute to unsustainable society. Even though Benyus acknowledges this fact, it has yet to be incorporated into the Biomimicry framework and approach.

The same is true for the Guidelines that were based on these Life’s Principles. Used alone, these Guidelines could still contribute to unsustainability. For example, “be resourceful and use what is available” could literally mean to some people that being resourceful is printing 20,000 brochures on virgin paper to communicate their message when only 12,000 are needed. However, using these Guidelines within the overarching definition of sustainability provided by the four Sustainability Principles means a literal translation of this should not occur because it would violate the Sustainability Principles.

Using the Guidelines for Effective Communication of Sustainability Messages as a tool within the FSSD can create synergistic interactions between them. The FSSD provides the comprehensive definition of sustainability and the overarching strategy of backcasting from principles of success. The Guidelines could help people better understand sustainability challenges and the need of adopting a strategic approach used within the FSSD. Moreover, nature inspired communication methods may help remind people of their own connection to nature, promote system thinking and enhance a humbling approach that the authors regard as essential when moving society towards sustainability.

4.5 Future Research

In addition to the previously mentioned idea of comparing communication theories to communication patterns used in nature, other possible future research topics presented themselves during this research process.

Humpback whales and email.

From the research done for this paper, it appears that organisms in nature often adjust their signals to changing environmental conditions. One clear example of this is the Humpback whale. This mammal will change the pitch of the song when in cold water to make the sound travel better. The whale does not wait to make this adjustment. It is done as a part of the communication pattern (Scott 2005). The message sent by the Humpback
The whale does not get lost because the signal has been adjusted to changing conditions.

In comparison, today’s modern society is overloaded with messages sent via email and other channels that highlight urgent social and environmental actions that are needed, such as climate change. These messages often get lost in the barrage of other emails arriving at the same time into a person’s inbox. The new and innovative social media methods such as Facebook, Twitter, etc. may be tackling this problem to some extent, but it is a slow development compared to some examples in nature that demonstrate how quickly signals and messages can be adjusted.

What can be learned from this?

At first glance the success of the whale’s method is due to its immediate adjustment to the environmental conditions. The feedback loop of information exchange is very short in this instance, so the whale’s message is more likely to be communicated successfully. Is this something that humans have lost track of? Do human communication methods need to adjust and change more quickly to adapt to changing conditions and needs? If so, how can this be done?

More potential research topics can be demonstrated in the following questions:

- What role does urgency play in effective messaging in either nature or in human society? For instance, climate change and its effects are urgent issues. Can something be learned from nature that can help promote the needed behavior change more quickly?

- What role do trust and honesty play, if they play at all, in successful communication patterns in nature? How does this relate to communication in human society and moving towards sustainability?

- What influence would culture, demography and other factors have on the suggested Guidelines?

- Communication is also essential in ecosystems; as complex environments they require communication to occur in multiple levels using various methods. Looking into how communication
works in ecosystems could provide valuable insights for human society. What in the communication of ecosystems help them self-organize and maintain balance? Can ecosystems serve as a model to improve the flows of information and cooperation in human society?

- Knowing that humans are a part of nature, are the suggested Guidelines more evident in indigenous cultures? If so, could a study demonstrate if modern society has somehow lost a link to some innate communication patterns?

- How does meaning making and symbolic language affect people’s perception of the message?

- How does the complexity of human interactions help or hinder the communication process?

### 4.6 REAL Change

Clear and effective communication is critical to moving towards a sustainable society. Exchanging the right information, at the right time, to the right person(s) can be one key to propelling the needed change forward by strengthening the understanding required for people to make the right decisions. Since REAL Change consists of a CORE and Petals Programmes that involve fostering cooperation across disciplines, a new theme of research focusing on communicating sustainability could be a new Petal in the overarching effort to help better “develop theory, methodology and practice for strategic sustainable development” (REAL Change 2010).

Within the Petal that focuses on communicating sustainability, the Guidelines developed in this paper could be further enhanced and used. It is highly recommended by the authors that the Biomimicry approach be considered seriously as a method to further improve the extent and value of research concerning communication of sustainability. Successful designs and processes found in nature have had hundreds to millions of years to develop, evolve and be tested. Therefore, any project that focuses on learning from nature’s genius could propel the initiatives moving society towards sustainability forward at a much faster rate.
5 Conclusion

Communication patterns in nature were studied in order to address the challenge of effectively communicating sustainability messages in today’s society. These patterns were determined from peer-reviewed articles, case studies, interviews with experts, lectures, books and online videos. The Biomimicry Guild’s Life’s Principles framework and Biomimicry approach were used in order to develop these patterns into the Underlying Patterns of Communication in Nature. These Underlying Patterns were then translated into user-friendly Guidelines for Effective Communication of Sustainability Messages. For the purposes of this study, humans were viewed as separate from nature, since the Biomimicry approach is focused on looking at non-human organisms in nature, in order to find solutions to challenges in human society.

Based on the overall observations and research of the authors, there were some patterns that show promise for improving human communication by introducing new or forgotten ideas into sustainability communication strategies. Examples of these patterns include: create short feedback loops; create a message using simple components in different combinations; use methods that do not create unusable waste; and conserve energy and/or optimize energy.

Overall feedback showed that communication patterns observed in nature could be used to improve communication of sustainability messages. This could be done through using the Guidelines as a checklist and a design tool when designing sustainability messages and methods for communicating the message.

Using nature inspired communication methods based on these Guidelines in conjunction with the Framework for Strategic Sustainable Development (FSSD) could create win-win interactions between them. The Guidelines could assist people in recognizing the importance of using the FSSD to move society towards sustainability, and enhance systems thinking. The FSSD provides a robust strategy devised from a science based definition for a sustainable society as framed by the Sustainability Principles. The aspect of using the Guidelines as a tool within the FSSD could provide opportunities for further research that includes testing them on a larger audience and providing recommendations for the use of them with specific target groups.
Nature inspired communication methods could enhance people’s understandings of the importance of sustainability issues, promote awareness and increase people’s willingness to take an active approach towards sustainability. This could be achieved by using the Guidelines and also because nature inspired communication can remind people of their connection to the natural world and inspire a new worldview.

From the cellular level to a whole systems perspective, all organisms are dependent on communication for their survival. Humans are no exception. Today, facing sustainability challenges on a global scale, our survival as a species is very much dependent on our ability to communicate and cooperate. The Guidelines presented here are a way to improve human communication when creating sustainability messages. These Guidelines encourage taking a humbling approach of seeing nature as a mentor rather than a supplier, as well as adopting an interconnected worldview. Both are habits that are urgently needed to help move society towards global socio-ecological sustainability.
References


Appendices

Appendix A: The Biomimicry Guild’s Life’s Principles Definitions and their Subfunctions
(The Biomimicry Guild 2010).

**CREATES CONDITIONS CONducive to LIFE** - a systemic approach or design that enhances the environment and foster the survival of species.

Optimizes Rather Than Maximizes: a systemic approach or design that synergistically resolves all factors in context.

- **Multi-Functional Design**: a systemic approach or design that moves beyond singular resolutions for different needs.

- **Fits Form to Function**: a systemic approach or design whose shape is determined by the need.

- **Recycles All Materials**: a systemic approach or design that keeps all materials in a closed loop.

Leverages Interdependence: a systemic approach or design that finds value through interactions.

- **Fosters Cooperative Relationships**: a systemic approach or design that promotes win-win interactions.

- **Self-Organizing**: a systemic approach or design whose components interact in concert to move towards an enriched system.

Benign Manufacturing: a systemic approach or design that causes no harm in its creation.

- **Life-Friendly Materials**: a systemic approach or design that is made using materials that do not harm life in any stage of its life cycle.

- **Water-Based Chemistry**: a systemic approach or design whose chemistry uses water as solvent.
• **Self-Assembly**: a systemic approach or design that leverages the natural affinities of components (usually molecules).

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**ADAPTS AND EVOLVES** - a systemic approach or design that alters in response to changing conditions.

**Locally Attuned and Responsive**: a systemic approach or design that is consistently adapted to its surroundings.

• **Resourceful and Opportunistic**: a systemic approach or design that skillfully exploits local resources and opportunities.

• **Shape Rather Than Material**: a systemic approach or design that uses form to minimize material consumption.

• **Cellular and Nested**: a systemic approach or design that is based on multiple units that fit within each other progressively from simple to complex.

• **Simple, Common Building Blocks**: a systemic approach or design that builds with locally abundant and accessible materials.

• **Free Energy**: a systemic approach or design that harnesses freely available energy with minimal outlay.

• **Feedback Loops**: a systemic approach or design controlled via the relaying of information within a loop.

• **Antenna, Signal, Response**: a systemic approach or design that matches information flows with receptors and actions.

• **Learns and Imitates**: a systemic approach or design that embodies information to enhance performance over time.

**Integrates Cyclic Processes**: a systemic approach or design whose processes follow a cyclic path.
• **Cross-Pollination and Mutation**: a systemic approach or design in which information is exchanged and/or altered.

**Resilient**: a systemic approach or design that maintains function following disturbance.

• **Diverse**: a systemic approach or design incorporating multiple forms, processes, or systems to meet a functional need.

• **Redundant**: a systemic approach or design that incorporates duplicated forms, processes, or systems.

• **Decentralized and Distributed**: a systemic approach or design whose forms, processes, or systems are not located exclusively together.
## Appendix B: Research Fields for Focused Study

<table>
<thead>
<tr>
<th>Research Field</th>
<th>Focus or Definition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Communication Patterns</td>
<td>Four common properties identified to maximize affectivity: conspicuousness, repetition, stereotyping and alerting components</td>
<td>Johnstone 1997</td>
</tr>
<tr>
<td>Animal Behaviour</td>
<td>Behaviors are adaptations which serve specific functions for the organism. Behavior requires that an animal obtains information about its environment. Need to understand how organisms perceive their environment</td>
<td>Scott 2005; Johnstone 1997</td>
</tr>
<tr>
<td>Biomimicry</td>
<td>Term used to describe emulating nature as a model to solve human problems</td>
<td>Benyus 1997</td>
</tr>
<tr>
<td>Biosemiotics</td>
<td>The functional cycle: the animal's sensing of the world, its actions, which in turn create consequences that are fed back into the animal's perception of the world, creating an ongoing knowledge-generating loop</td>
<td>Kull et al 2008</td>
</tr>
<tr>
<td>Consensus Decision Making</td>
<td>Members of a group choose between two or more mutually exclusive actions with specific aim of reaching a consensus</td>
<td>Conrad and Roper 2005</td>
</tr>
<tr>
<td>Decentralized Organization and</td>
<td>Insects act on local information and make single decisions based on simple rules defined locally</td>
<td>Kostroulis 2007</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision Making in Animals</td>
<td>A computer model developed by scientists proves that lower cognitive organisms can reach consensus decisions about preferred motion direction for the group, when the group members do not know which members of the group, if any, has the information of preferred direction</td>
<td>Cousin et al 2005</td>
</tr>
<tr>
<td>Diffusion of Innovations</td>
<td>In order for a new idea/habit to be adopted by society, a process of 5 stages need to take place for each individual. The stages are: knowledge, persuasion, decision, implementation and confirmation. In order for adoption to occur, an individual has to develop awareness to the new idea, but also to form his/her own opinion and positive attitude towards it. For the latter to occur, interpersonal communication is important</td>
<td>Rogers 1995</td>
</tr>
<tr>
<td>Ecopsychology</td>
<td>An evolving field focusing on, but not limited to, the intimate relationship between nature and human psychology. The idea that the human mind and nature do not work independently of one another</td>
<td>Smith 2010</td>
</tr>
<tr>
<td>Human Behaviour</td>
<td>Positive correlation between attitudes and values; knowing one's attitudes helps predict one's values and vice versa. Attitudes and values may be contradictory with one's behavior. Best way to change one's values and attitudes is to make one's change his behavior</td>
<td>Adcock and Ben. 1976</td>
</tr>
<tr>
<td>Plant-Animal Interactions</td>
<td>Communication between plants and animals using visual signals</td>
<td>Schaefer et al 2004</td>
</tr>
<tr>
<td>Psychology of Climate Change</td>
<td>Study of the emergence and complexity of the psychological reactions behind positive and negative reactions and beliefs relating to climate change</td>
<td>CRRED 2009</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
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<tr>
<td>Quantum Responses</td>
<td>Individuals respond only when they see a threshold number of individuals perform a particular behavior</td>
<td>Ward et al 2008</td>
</tr>
<tr>
<td>Swarm Intelligence</td>
<td>Collective behaviour that emerges from a group of social insects</td>
<td>Bonabeau and Meyer 2001</td>
</tr>
<tr>
<td>Theory of Planned Behaviour</td>
<td>Intentions to perform a specific behaviour influenced by three main factors: the individual's beliefs and attitude towards the behavior, the individual's normative beliefs and tendency to confirm with the norm; and the individual's perceived amount of control, or the degree to which the individual believes in his/her ability to perform the behavior</td>
<td>Ajzen 2006</td>
</tr>
</tbody>
</table>
Appendix C: Mind Map of Guidelines for Effective Communication of Sustainability Messages
“Man is not imprisoned by habit. Great changes in him can be wrought by crisis - once that crisis can be recognized and understood.”

Norman Cousins