

Regenerative Computing: De-limiting hope.

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ABSTRACT

In computing there is a small but growing community who desire to make sense of the role of computing in a world with limits. This community has provided a much needed critical perspective on what has otherwise been computing's contribution to a worsening world state, or at best a weak sustainability. But, by framing the biophysical and social environment as *limited*, there is a danger of adopting a negative and overly pessimistic approach with the effect of marginalising our message and contribution to computing. Previous attempts to address the tension between a limited world and a positive approach have been foundered on concerns that a techno-utopia is not only unrealisable but efforts to achieve it are exacerbating the problem. In this paper we explore the potential for an explicitly positive approach to computing within limits research: *regenerative computing*. We describe what regenerative computing within limits might look like and suggest a way forward. We expect this new approach to transform the computing and sustainability discourse, and empower the computing within limits community to become ambassadors of hope and regenerative sustainability.

CCS CONCEPTS

• **Information systems** → **Collaborative and social computing systems and tools**; • **Human-centered computing** → **Collaborative and social computing**;

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1 INTRODUCTION

To begin, it is worth stating clearly that the authors of this paper are in complete agreement that the finite-ness of our planet sets hard non-negotiable limits on human activities. In “Doughnut Economics” Raworth [27] extended the planetary boundaries [31] to describe a “safe and just space” framework where sustainability is visualised in terms of a doughnut-shaped space where resource use is high enough to meet people’s basic needs (the inner boundary), but not so high as to transgress planetary boundaries (the outer boundary). Recently this framework has been tested by O’Neill et al. [20], who argue that Raworth’s doughnut-shaped space “could be a vanishingly thin ring” as only Vietnam comes anywhere close to meeting social thresholds without transgressing planetary boundaries. We also agree that as a significant discipline, computing must engage in a discussion about its current and future role in that constrained environment [14]. As Tomlinson describes “we as a discipline have largely failed to appreciate the need to investigate, design, and build technologies that may be of use on the “downward slope” of social complexity. Futhermore, ICT may itself play a role in bring about collapse” [38].

Pargman and Joshi [22] describe two alternative approaches...

“On the one hand, some, design “sustainable” information technology based on visions of the world that do not really question limits to continuous economic growth and, on the other hand,

others embrace the design of information technology from stances that acknowledges limits (i.e., economic, ecological, energetic)."

...and we firmly place ourselves in the second group.

Silberman writes of an uncertain navigation:

"Effective trans-scalar responses to global change will require that the global networked information-industrial society become a fundamentally different society and one cannot fully map the road from here to there from here, as if from above; rather, the process is one of 'navigation', in which we discover the road as we walk it: any successful quest for sustainability will be a collective, uncertain and adaptive endeavour in which society's discovering of where it wants to go is intertwined with how it might try to get there." [34]

So where might this navigation lead us? And how can computing help us get there?

The community involved in the development of a research focus in Computing within Limits (LIMITS) concerns itself with preparing for future that is more constrained than our (apparently) abundant present. As an example, our "modern communication systems rely on assumptions of centralised systems and underlying infrastructure that make them vulnerable to computing within limits scenarios" [32]. After studying computing networks in refugee camps, Schmitt et al. concluded that "present-day networks are ill-prepared for collapse and will be unsustainable if we continue our current trajectories" [32]. Jang similarly considered [10] limits to longevity of existing of hardware and software survival after collapse - how long could we keep the machines running? In response to such concerns, researchers are focusing on technologies and processes for computing systems that can continue to operate, or be re-established, in a situation of societal collapse (e.g. Raghavan's internet quine - a collection of devices, protocols, manufacturing facilities etc to re-establish a network [25]).

But the question arises - is this defeatist? Have we given up and are merely navigating to a more comfortable demise? LIMITS has its origins in papers with titles such as "what if sustainability doesn't work out?":

"Despite significant efforts to mitigate global change being exerted across many elements of global civilisations, it is not clear that these efforts (sustainable mitigation) are sufficient to place humanity on a path that avoids the grave consequences of this change...The manner in which humans adapt to the changes will define the future of civilisation." [40]

This, of course, is not an unreasonable response. The challenge expressed by O'Neill [20] is almost mind-boggling. But not impossible. O'Neill describes two changes required - a fundamental restructure of the provisioning system to enable basic needs to be met at a much lower level of resource use (two to six times more efficient); and a focus on social equity and sufficiency - "recognising that over-consumption burdens societies with a variety of social and environmental problems, and moving beyond the pursuit of GDP growth to embrace new measures of progress...(possibly) degrowth...and alternative economic models". Both of these things - efficiency and new models to support sufficiency - are things that computing can help with.

So the authors of the current paper are not ready to give up on the potential for a sustainable future nor on computing's contribution to that [14]. The authors' definition of sustainability:

- We do not see sustainability as sustaining systems in a status quo.
- We see sustainability as co-evolving and co-creating society, where technology and eco-systems support both humanity and the natural environment.
- All development of technology considers its role and impact on natural and ecological systems whilst transitioning away from harmful forms.

Crucially, we see this as a positive journey of positive system change for socioecological restoration. These ideas are brought together in a Transformation Mindset (developed in context of community development [16] and extended to computing [15]).

If we wish to transform ourselves and society, we need to embrace:

- (1) Socioecological restoration over economic justification
- (2) Transformative system change over small steps to keep business as usual
- (3) Holistic perspectives over narrow focus
- (4) Equity and diversity over homogeneity
- (5) Respectful, collaborative responsibility over selfish othering
- (6) Action in the face of fear over paralysis or wilful ignorance
- (7) Values change over behaviour modification
- (8) Empowering engagement over imposed solutions
- (9) Living positive futures over bleak predictions
- (10) Humility and desire to learn over fixed knowledge sets.

Yet we see value in LIMITS. As Pargman [21] describes

"Abstracts submitted to LIMITS are expected to differ from mainstream computing research.

Mainstream computing research typically assumes futures that are little else but extrapolations from the recent past, and where the direction ever and always can be summarised by terms such as 'more', 'better' and 'faster'.

In this perspective, LIMITS is preferable to several alternative options: deluded optimism that pays no attention to sustainability (most of computing) (cf. [14, 15]); Guilt assuagement (see discussion in [13]); solutionist belief in techno-utopia (see [41]) with associated "green myth" [17]; weak and impoverished sustainability [18]; and so on.

In particular, LIMITS provides the critical lens missing from much of sustainable computing [3].

So what's the problem? Our objection is in the language, because this reflects a stance that we do not find helpful. We struggle with the negative framing of "thwarting bleak futures in the abundant present" [21], or the dismissing of hope as being completely unrealistic:

"It is possible to cling to hopes about human ingenuity and the success of large-scale engineering projects (carbon capture and storage, fusion power, massive scaling-up of renewable energy sources, geoengineering etc.) for much longer than it is possible to deny a reality of decreasing rates of return of limited resources." [21]

Similarly, Raghavan [24] responds to Kelly's attempts to find a middle ground between techno-utopia and technophobic [12] by arguing that beneficial computing is impossible as it is beset with temporary solutions that don't work, to problems that are in reality unsolvable. Raghavan suggests an alternative "benign computing" which is a rejection of the utopian notion of creating new technology that is strictly 'beneficial' or that advances 'development'. Instead, the aim of benign computing is computing that is of a scale and structure such that even if its downsides dominate, its overall harm is small because they are made apparent. So benign computing is rejection of utopian notions of beneficial computing.

So, again, why does this matter? It matters because it maps the space of a future world. Toyama's preliminary of taxonomy of sustainable computing has three scales: impact, intention, effort. Crucially on the impact scale there are three negative items on the scale to one on positive and even that is barely positive "contributes to movement toward a globally sustainable equilibrium. Actively moves things toward net resource replenishment" [42].

This movement towards an equilibrium is hardly an aspirational goal that will provide a basis for Silberman's navigation [34].

In the remainder of this paper we argue for an alternative approach - regenerative computing within limits.

2 ARE WE JUST AVOIDING ADMITTING DEFEAT?

Pargman [21] described an "abhorrence of admitting defeat" - that is, that accepting resource depletion is seen an abhorrent idea. He discusses Greer's suggestion that [5] that the idea of a climate catastrophe to "many people is preferable compared to admitting that some of the most important factors for upholding current levels of affluence and technological developments lie outside of human control".

The idea that humans are not the masters of the universe and that we are not even the masters of our own destiny on this planet is abhorrent - not the least to deviously clever and immensely rich entrepreneurs who have created something (e.g., wealth) out of nothing (e.g., ephemeral ideas or "free" natural resources). [21]

We do not see ourselves in this category of denying that there is a problem. Knowles and Eriksson [13] argued that admitting a problem is the first step and that ... we need to be radical in our ambitions (which Knowles and Eriksson both describe on a personal level but fall short of in research described).

Nor do we see Limits as being something that we can deal with later. We fully agree that those who point out that a future Limits is an affluence-centric view that ignores the state of much of the human (and non-human world):

"The view that global crisis will occur in the future reflects a parochial, developed-world perspective. For two-thirds of the world's population, crisis of scarce resources, inadequate housing, deplorable conditions of health, and starvation are already at hand" [40]

Computing has no miracle cure for this. Chen [4] argues that while others had argued that crisis, development and sustainability were *like* limits, Chen argues that "we should consider these context to *be* limits scenarios: The collapse 'future' is already here". Chen suggested limits-aware computing research should focus on these problems to make a difference today while preparing for further future collapse. He describes challenges including that of developing unifying goals "from the view of collapse described, we need to articulate our goals and determine the best path toward our desired future". For our purposes here, the crucial phrase is "desired future". Chen later identifies "the problem of convincing the public that limits is important".

So what does LIMITS have to say about a desirable future? Not a lot. Instead we are guided by the bleak question "What if sustainability fails?". And this very rhetoric could be a self-fulfilling prophecy:

“The environmental apocalypse, in turn, is precisely what will happen if the world does not listen to warnings of imminent doom – and the growing fixation on a prophetic role of this kind is a subtle but effective way of encouraging environmental activists to express their warnings of imminent doom in such a way that, in fact, the world will not listen.” [5]

We do recognise that LIMITS has positive aspects. Tomlinson [40] suggests that the new kinds of research align with work already underway so that “if we have a miracle” this work will not be wasted as it overlaps with HCI, and much of the world is already living within limits. “Will this work be wasted?”. It is also clear that much of the work that would be useful in a limits scenario does double duty as helping mitigate the likelihood of collapse scenarios.

3 HOPE AS LIMITED

LIMITS is welcoming in its consideration of limits. From physical limits affecting computing’s ability to operate [10, 32] and affects on computing [23], there have been almost as many new limits identified as there have been papers in the LIMITS corpus and many of these have are sociological rather than technical. These have included: reduced growth itself [37]; internet freedoms [19]; gender imposed [1]; or policy modelling [11]. Some of these identified limits question the nature of limits to the paradigm of Human Computer Interaction [22] or the human “needs and requirements” at the centre of design decision Human Centred Design [36].

In this mix of limits, some authors [6, 13] have considered social and psychological limits that hinder people from taking sustainable actions: psychological limits, knowledge and skill limits, and social limits. Knowles and Eriksson [13] argue that “there is little computing can hope to achieve [as] these psychological limits to computing do not only concern the users of our system... but also ourselves as researchers within computing”. They describe feelings that are painful, guilt-ridden and fraught with emotions.

We argue, that the effect of all these limits is that hope has also become limited. While most LIMITS authors take pains to avoid it, the “limited resources in futures of scarcity and collapse represent a future that is often perceived as scary, negative and difficult - and sometimes even described as apocalyptic” [28]. While we may be “helping people recognise immorality of sustainability inaction” [13], we’re not offering an alternative vision to guide Silberman’s navigation [34].

This matters because LIMITS has rightly rejected visions of deluded business as usual; the solutionist techno-utopia; and apocalyptic visions - leaving a dystopia. It is of course,

slightly more nuanced than this, Remy argues that [28] LIMITS provides a new lens for SHCI research “instead of treating the future as binary (a perfectly sustainable society or the end of the world) the more likely future probably lies somewhere in between”.

Our argument is that another alternative - a **thriving future within limits** has been largely overlooked.

But this not from a lack of trying. In introducing Collapse Informatics, Tomlinson et al. [38] proposed ideations and context scenarios that are inherently rooted in positive everyday practice: a climate change habitability index, and “wisdom of years” - a system for knowledge sharing of alternative lifestyles. There are, they say “abundant projects...that could improve the quality of life in collapse contexts” and would also mitigate against collapse. But why aren’t such projects dominating the LIMITS conferences? Perhaps it is how they are presented. Tomlinson was careful to say that they were not considering a dramatic and immediate apocalypse, and suggested everyday practice as focus: “through this research, we envision the possibility of a future characterised by scarcity and shrinking opportunity, and seek to make that future a better place”. But this better place is prompted by the threat of a “vast envisionment of civilisational dystopia” and action is driven by people “rattled by disturbing anticipations of a dark future”.

It appears to us that dark side of LIMITS is swamping the light. In paper after paper we see glimmers of hope but then the doom floods in: Ringenssen [30] presents challenges to the city and describes euphorically (and probably ironically) “smart to the rescue”, but then turns dark again and we’re left with smart city being an impossible dream. Meanwhile Remy and Huang [29] start negative, tease, but sink again: “Both theories [Moore’s doubling law Jevon’s rebound effect paradox] are an almost paralysing obstacle when tackling obsolescence” and combined with “industry’s disinterest of resolving obsolescence... paint a depressing picture for the future of sustainability research”. Although they follow this with a “however” which the reader might think is going to lead to some hope, it only leads to a discussion that increased consumption cannot be infinite, so the growth of computing must “hit a ceiling sooner or later”. It might be a minor difference in language but in Hilty [8] the “current anytime culture” is replaced by “people living in self sufficient region would *have* to adapt their lifestyles to pace of renewable energy” (our emphasis).

This lack of positive vision and a negative framing has several consequences, but perhaps the most important is a disempowerment. We believe that a perceived doomsday ethos - even if not intended by active LIMITS researchers could be actively discouraging people from engaging in LIMITS. Beyond participation, this effect can also be seen in how LIMITS research is evaluated - without a coherent vision for

the future underpinning a cohesive evaluation framework, the field has “manoeuvred itself into a difficult spot” [28].

Others have described uneasy and uncomfortable relationships. Wangel [43] describes students in a course introducing media technology post-graduates to sustainable development who “had a hard time imagining other futures than a continuation of the last 50 years of exponential development in the field of computing”. The course “presented two very different future scenarios to the students: a “vanilla sustainability future” where current sustainability challenges can be solved through smart application of ICT and media technologies and a “doomsday sustainability future” where instead we will have to face climate change, resource depletion or other “undesirable” scenarios”. Their students “oscillated between despair and hope” and this is celebrated: “by allowing, or even forcing students to wrestle with not just ‘the solution’ but also ‘the problem’, by exploring and testing causality and dependency, ethics and values, innovation and conservation, we seek to promote a kind of learning rarely included in engineering education”.

Tomlinson [39] et al. also carefully managed the emotional journey of students in a course introducing Limits concepts with “happy weeks”:

“One of the challenges of teaching and responding to sustainability concerns in general, and those in this course in particular, is to avoid a sense of despair or hopelessness in the presentation. The problems are overwhelming, but we felt that creating some enthusiasm for tackling them and helpful ways of thinking about them was an important point of offering the course. As a result, we structured the course as a “descent” into the problems in the early weeks, and then an “ascent” to solutions, ideas for solutions, and case studies of successes in the later weeks.”

Sometimes the desire to fit into a negative frame means that even positive stories described in LIMITS papers are treated to a negative spin. In perhaps the most positive (but apparently overlooked) papers in the LIMITS conference corpus, Gui and Nardi [6] argue that we should change the focus from limits and less to one of fostering “Mores”. In a study of Transition Town (TT) Totnes, they describe how “being surrounded by like-minded people brought emotional courage to counter psychological limits” and suggest that “perhaps the words of these TT Totnes participants can help us make sense of our fears... staring down ruinous futures requires the aid and comfort of a cohesive community”. This was so remarkable in LIMITS context that it formed the basis of their discussion:

“It was remarkable how many times we heard the word “happy” in connection with TT Totnes

activities. Participants drew energy and excitement from one another. The experience of working toward sustainability developed into much more than sustainability — it became a blissful experience of what Durkheim (1995) called “collective effervescence” when people feel joyously connected to one another. Although motivated by grim projections of future decline, the empowerment of learning how to “make things happen” and the strong feelings of social and moral connection left people feeling “positive” and “happy.” ” [6]

This focus on developing a community vision and of de-liberate positivity is a fundamental feature of the Transition Movement [9]: “Transition is an ongoing social experiment, a movement of communities coming together to re-imagine and rebuild our world through a process of creating healthy human culture”:

“By coming together, they are able to create solutions together. They seek to nurture a caring culture, one focused on connection with self, others and nature. They are reclaiming the economy, sparking entrepreneurship, re-imagining work, re-skilling themselves and weaving webs of connection and support. Courageous conversations are being had; extraordinary change is unfolding.

We foster positive visioning and creativity: our primary focus is not on being against things, but on developing and promoting positive possibilities. We believe in using creative ways to engage and involve people, encouraging them to imagine the future they want to inhabit. The generation of new stories is central to this visioning work, as is having fun and celebrating success.

One of the key challenges with creating a low carbon, more resilient future is imagining what that might be like. Vibrant, diverse, delicious, connected and nurturing, or eating mouldy potatoes in a damp cave? Transition groups are great at helping people create visions of the future they’d like to see and then start taking steps towards it.” [9, p. 8]

Despite such a strong statements, when Pargman and Joshi similarly described the Transition Town Movement as “striving toward alternative ways of living” and “the loci of social experimentation, learning and innovation that are key for exploring questions” [22], there was no mention of the vision or the deliberately positive approach. In their otherwise useful conclusion there is no hint of a vision:

“The central-home message is that: we are not only part of our environment but we are our environment and we evolve together with it and vice-versa...[and]...Reflections about computing within limits might benefit from acknowledging that the relation between computing and the environment is 1) of a co-evolutionary nature, 2) presents a multidimensional structure, 3) is reflected in transactions between material and semiotic resources, 4) is, analytically speaking, better grasped with contextual analysis in a trans-disciplinary action research orientation.” [22]

We believe that this LIMITS treatment of Transition does a disservice, both to Transition and a sustainable future. What a missed opportunity to inject the notion of a positive vision into the LIMITS lexicon. But instead of “imagining the future you want to co-create” [9] we are back to the not-deluded-but-not-apocalypse-either blandness. And the danger is that without a positive vision, LIMITS can only ever hope to slightly ameliorate a damp cave existence.

So, while Penzenstadler hopes their “(LIMITS) research never becomes relevant to put into practice” [23], we have an opposing view - we fervently hope that it does - but for that, LIMITS has to change.

To unpack where our argument is at this point, we reference a paragraph from Knowles and Eriksson [13] (whose paper argues that admission contains a glimmer of hope).

We agree with this:

“We cannot any longer live in denial of climate change and resource scarcity, and we cannot any longer live in denial of our responsibility to act and support change towards a more sustainable and resilient society.”

We disagree with this (we think it will fail if it is framed in this manner):

“But we must acknowledge that this journey will be painful, guilt-ridden and fraught with emotions;”

We think a refocused LIMITS can help with this:

“...it will be computing within psychological limits. And for those who might not concede the extinction of humanity as preferable to a resource constrained future for our species, there is still the difficulty in perceiving hope in humanity’s ability to cooperate toward solving this wicked problem. It is certainly deflating to the spirit to recognise the power wielded by those who seem content to drive humanity off a cliff.”

And we agree with this:

“Computing within limits [LIMITS] has an important role in defining what a future within limits could be; but to be successful we will need to learn from, and perhaps become involved in, fundamental research into how to communicate this reality in a way that is understandable without threatening people with apocalyptic rhetoric. We also have a role in helping people come to grips with the enormity of the problems we are facing, but doing so without them getting stuck in apathy and negative emotions. And all the while, we must work towards developing technology that does not make the problem worse, and instead leads to a more resilient society.”

So, at best, LIMITS can be seen to have an uneasy relation with positivity. We seek to change that. We wish to develop a positive take on LIMITS. Before we do so, however, it is worthwhile considering how other LIMITS authors have considered the obvious tension. We ask ourselves, like the wry question of military intelligence, is Positive LIMITS an oxymoron?

4 IS POSITIVE LIMITS AN OXYMORON?

In the writings of some LIMITS authors, the concepts of Limits and Optimism are diametrically opposed. Pargman [21] channels Welzer [44] who instructs optimists to stop reading his book at a certain point after which he describes his bleak view of a climate change future. This provides the framing for Pargman’s proposal for different stances - with the scale of response determined by the urgency. Also at this pessimistic end of the spectrum - although perhaps more entertaining - is dystopian design fiction [35]. Tanenbaum describes how “collapse informatics and the LIMITS community have a problem of intelligibility: the harder we work at communicating insights into dire futures, the more difficult it becomes to overcome the visceral resistance to engaging with the harsh realities our civilisation faces” but that these “likely futures that are frightening and seemingly hopeless” can be engaged with via well crafted narratives”. But not all LIMITS researchers see Limits and Optimism as diametric opposites. Pargman and Joshi [22] describe a “healthy tension” and Knowles and Eriksson, for example, in discussing overcoming psychological barriers described a much more complicated relationship [13]. While a “difficult path”, they argue that “we as researchers are going to have to overcome our own psychological barriers toward becoming much more radical in our ambitions”. We believe these radical ambitions are key - Knowles and Eriksson haven’t given up on hope in their research or in how they live their lives. Similarly this contradiction, we believe, reflects a healthy tension in a field under development. A tension between thinking, designing

and building technology for a world without economic and ecological limitations (and primarily regulated by a continuous growth of finance capital), and thinking, designing and building technology for a world with finite natural resources. Returning to Gui and Nardi's [6] study of Transition Town Totnes, where the observation of happy people led the authors to conclude

“Sustainability in computing has largely focused on a theme of less: less energy consumption, less waste, less obsolescence. TT Totnes shows that we can also focus on a generative, positive theme of more to counter limits: more community, more shared activity, more collaboration, more shared moral sense of sustainability, more neighbourliness, more empowerment. Indeed, we believe that these “mores” may be imperative to real changes in sustainable behaviour. TT Totnes offered collaboration, celebration, excitement, joyfulness. A moral sense of sustainability, a sense that ordinary people can indeed make a difference, was grounded in positive, collective, community interactions. How to design technology to foster the “mores” is a genuine challenge we should address.”[6]

To answer our question: No, Postive LIMITS is not an oxymoron - it just needs work.

5 REGENERATION

We see LIMITS and sustainability researching in computing as the main challengers of what “*better*” means in the context of computing. There are a number of existing business models, frameworks and practices beyond computing that prescribe to models where “*better*” doesn't mean technological advancement, it means recovery, transition, transformation and regeneration. *So how can we be positive and sustainable?*

A model to learn from: Designing for Hope

“As individuals we have followed a journey familiar to many advocates and practitioners – alternating between optimism, cynicism and outright despondency, yet always searching for a message of hope.” [7, p. 9]

Hes and du Pleiss provide a response filled with hope ingrained in a vision of regenerative sustainability [7]. This vision challenges the common discussions of doing less and reductionist arguments for sustainability. Their thesis “*Designing for Hope: Pathways to Regenerative Sustainability*” grounded in built environment and architecture research makes a strong case for regenerative sustainability that presents humans as not only consumers but as powerful actors in a community [and ecosystem] with endless positive actions

for ecology and other species within an ecological worldview (e.g. producing resources, developing eco-system services). One vital step in this journey is moving towards the Biophilia Hypothesis where the narrative of fear [of collapse, of resource depletion, of having less, of missing out, of things staying the same] is moved towards “one of love through the conscious re-integration of humans with nature and acceptance of our innate need for that connection.” [7, p. 21] A consequence of the Biophilia Hypothesis is Biophilic design, where design process more strongly consider how humanity is part of nature, and how to follow its laws and designs. Hes and du Plessis posit that through Biophilic design thinking we can re-integrate with nature, and through doing this it is possible to move from scarcity to abundance by better “contextualising understanding of the story of place and partnerships with nature that integrate natural and social systems” [7, p. 21].

We focus on regenerative sustainability here as the model for Regenerative LIMITS as we believe it has found the sweet spot of recognising the limits and describing a positive future. It carries a fundamental belief that while “there will be many painful and heart breaking transitions and system collapses”, this is an opportunity “to create an alternative model of development that will lead to a thriving future”. This “thriving” is rooted in a living-systems-based worldview and is an explicit rejection of the mechanistic view of sustainability that has so laced the LIMITS with doom.

“This book is a hopeful response to sense of doom that pervades so much of the sustainability discourse and the feelings of hopelessness and powerlessness that come with facing challenges that seem insurmountable.” [7]

Regeneration is “rethinking [the] world in terms of systems and relationships” [7, p. 131] with “humans as co-evolutionary partners with nature”, a belief in a “positive and abundant future” and “Mindful, contributive engagement”. This worldview may also lead us to question some base assumptions of LIMITS: “The very steps we take to optimise and increase efficiency in the system reduces its resilience” [7, p. 17], or to develop more nuanced understandings that [may] contradict some of the seminal and popular works of the LIMITS and related communities (e.g. encouraging non-attachment cf. [2, 29]).

Whilst there may be an unclear union between computing and the work of Hes and du Plessis we see a number of opportunities in their vision to help describe a vision for Regenerative LIMITS meet:

- (1) **Move away from present fear-based narratives** - the predominant narrative of sustainability is that of scarcity, negative impacts and disruptive change in the face of growing socioeconomic needs. Regenerative

LIMITS must decouple from these narratives and move towards a vision where endless positive actions (of actors) are made possible in a system tied much more closely an ecological worldview.

- (2) **Develop a clear vision of what a viable alternative might look like.** A next step for Regenerative Limits is describe computing's contribution to a vision of Regenerative Sustainability through developing narratives and stories of technology and computing that are more closely intertwined with nature, ensuring that these narratives and stories demonstrate how projects fit into and contribute to wider systems.
- (3) **Move beyond efficiency as the primary lever available to computing.** - These new narratives should look to nature and ecology to demonstrate the interplay between computing, society and biological systems where limits of these systems are respected and worked with.
- (4) **Integrate ecological worldviews into computing's narratives and processes** both the theory such as living systems and deep ecology, and values sets:
 - Integrity - maintaining the wholeness of [wider] systems, ensuring that structure and relationships remain intact and functioning as they should.
 - Inclusivity - "interacting with the world in its entirety" [7, p. 35], engaging and integrating with all dimensions, levels of existence and knowledge.
 - Harmony - all elements cooperate through relationships that are respectful in order to avoid dissonance.
 - Respect - all parts of the world have intrinsic worth and all existence is part of the extended self, and therefore all self-respect is extended to mutual respect for the world.
 - Mutuality - "we are in this together, and what happens to 'others' will also have an effect on self" - see: compassion, treating others the same as yourself.
 - Positive reciprocity - "reciprocating in a way that is of benefit to and advances the relationship between self and extended self" [7, p. 35].
 - Fellowship - an extension of mutuality and positive reciprocity, where the world is co-created by humans in partnership with nature.
 - Responsibility - morally accountability for the consequences of our actions in an uncertain and unpredictable world
 - Humility - change is constant, we cannot know the true consequences of our actions
 - Non-attachment - In order to adapt to changing circumstances it is important to uphold non-attachment in order to decouple from "the futility of trying to hold onto anything in an ever changing world including ideas, dogmas and strategies" [7, p. 36]

- (5) **Examine principles and assumptions of LIMITS for alignment with Regeneration.** An essential early step for Regenerative LIMITS is to challenge LIMITS by critically reflecting on how these principles and assumptions need to change to speak to Regenerative Sustainability (for example, how does societal refactoring [26] align with socioecological understandings of resilience?).

It is essential that these opportunities are tackled to serve as a first step in Regenerative LIMITS that lead towards 'Positive Development' (cf. [7, ch. 5]), where an ecological world view is observed and respected, the ecological base is increased, public estate is increased through education and cultural integration, new services are designed as eco-services that help enrich and protect ecology, and a green optimum is reached where "everyone, including nature, [is] better off than before" [7, p. 94].

Through our analysis we have barely scraped the surface of what Regenerative Sustainability and Regenerative LIMITS could look like. We look in future work to further muse on the work of Hes and Du Plessis [7] with an eye to a more thorough synthesis of the approaches and theories that they present. For now the ball is in our (the authors) court to respectfully integrate designing for hope and pathways towards regenerative sustainability into LIMITS.

Designing for more than hope

This all feeds into one overarching theme that we think is essential in the LIMITS community... *hope*. Our aim to use messages and strategies for ecological world view to help develop digital ecosystems, ecologies and systems that inspire hope and regeneration whilst thriving within Limits. It is essential that we as a community understand that there is no one right answer or approach to finding positivity in LIMITS, especially in a world view where uncertainty, and change must be embraced. To be blunt, something as important as LIMITS and the future of global socio-technical systems must not be tied to one mode or direction. In our mind Regenerative LIMITS encourages the diversity and inclusion of knowledge that allows for much more fluidity in its approach to developing a narrative for the existence of computing in a world with limits. Regenerative LIMITS embraces this fluidity through non-attachment, harmony, co-evolution and co-creation to help design and build a more resilient, hopeful Biophilic future.

We see a number of other opportunities for us as researchers as well as the broader community to learn from where transformation can be wrapped in positivity. Future work would benefit from exploring societal therapy, permaculture, Transformation Mindsets [16] [15], Design Thinking, transition [17], Future Studies (applied well to engineering

by [43]), Appreciative Inquiry, Liberative Voices [33] and so on.

It is not the intention in this paper to provide a blueprint for Regenerative LIMITS research and a more fluid future - we think that such a task will take much discussion, commitment and evolution of the whole LIMITS community. But we do suggest one activity that might kickstart this process. In the style of the design fiction described above [35], we propose a positive take on a micro-design fiction:

“I’m so happy I adopted <insert my favourite Liberative Voices [33] pattern card> approach to my Regenerative LIMITS research, it has enabled me to make a real positive difference to <what do I care about?> by <...>.”

6 CONCLUSION

In this paper we have attempted to identify and unpack the impact of the negativity that pervades the ethos of LIMITS. This is not intended as a personal attack - indeed, with one exception, the LIMITS authors who we know are otherwise enormously positive people. We appreciate the scale of the threat but struggle with the doom-laden focus of the research. We briefly introduce an alternative focus - a positive approach to LIMITS where we reclaim “abundance” and “better” from the clutches of the deluded techno-utopian optimists as thriving within limits. We promote a first step towards Designing for Hope and Regenerative LIMITS that is highly motivated by Biophilic Design and an ecological world view. We look forward to discussing these ideas - of “imagining the future you want to co-create” at LIMITS. Oliver will bring the doughnuts.

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