MABON, L. 2019. Enhancing post-disaster resilience by 'building back greener': evaluating the contribution of nature-based solutions to recovery planning in Futaba County, Fukushima Prefecture, Japan. Landscape and urban planning [online], 187, pages 105-118. Available from: https://doi.org/10.1016/j.landurbplan.2019.03.013

Enhancing post-disaster resilience by 'building back greener': evaluating the contribution of nature-based solutions to recovery planning in Futaba County, Fukushima Prefecture, Japan.

MABON, L.

2019

OpenAIR @RGU

This document was downloaded from https://openair.rgu.ac.uk

CC BY NC ND

Accepted for publication in Landscape and Urban Planning *31 March 2019*

Enhancing post-disaster resilience by 'building back greener': evaluating the contribution of nature-based solutions to recovery planning in Futaba County, Fukushima Prefecture, Japan

Leslie Mabon
School of Applied Social Studies, Robert Gordon University, Aberdeen AB10 7QG
E: l.j.mabon@rgu.ac.uk

Abstract

This research evaluates the contribution of nature-based solutions to urban resilience in post-disaster situations. Post-disaster recovery planning is an opportunity to 'build back greener' by fostering ecosystem approaches towards social and ecological resilience. Yet understanding of specific post-disaster resilience benefits which nature-based solutions provide is still emerging. This paper contributes to this field through evaluation of how ecosystem approaches bring resilience benefits in Futaba County, Fukushima Prefecture, Japan, following the 2011 earthquake, tsunami and nuclear disaster. Content analysis is undertaken on disaster recovery plans produced by the 8 municipalities in Futaba County. The ecosystem services included in each plan are identified, as well as the extent to which municipalities are capable of assessing the services provided. This is supplemented with insights from field visits and wider documentation produced by the municipalities. The analysis shows that cultural ecosystem services feature especially strongly within the plans, and that these cultural services are critical to recovering sense of identity and pride post-disaster. However, the analysis also indicates that municipalities may lack the technical

competence to assess ecosystem services, especially in a post-disaster setting where resources are stretched. One implication from the research is the need for further consideration in other empirical contexts of how cultural services – especially citizen participation - can be integrated with more technical approaches to post-disaster ecosystem management. A second implication is that whilst ecosystem approaches offer post-disaster resilience benefits, these should be an aid to recovery and not a substitute for long-term support from national governments.

Keywords: disaster risk reduction; Eco-DRR; Fukushima nuclear disaster; nature-based solutions; resilience.

HIGHLIGHTS

- Disaster recovery in Futaba County, Fukushima, socially and ecologically complex;
- Analysis of ecosystem services in municipal recovery plans of Futaba County;
- Cultural ecosystem services significant in restoring sense of pride post-disaster;
- Traditional ecosystem practices may balance participation with technical approaches;
- Need technical competence post-disaster to realise nature-based solution benefits.

ACKNOWLEDGEMENTS

This paper has been developed as part of the project ‘Building social resilience to environmental change in marginalised coastal communities,’ funded under the Economic and Social Research Council-Arts and Humanities Research Council UK-Japan Social Sciences, Arts and Humanities Connections scheme (Grant Number ES/S013296/1). Special gratitude

is extended to Akihiro Yoshikawa of Appreciate Fukushima Workers for support with site visits and for sharing his rich knowledge of Futaba County. The author is also grateful to all citizens of Futaba County and Fukushima Prefecture for their support and encouragement during fieldwork.

1. Introduction

1.1. Urban resilience, nature-based solutions and 'building back greener'

The purpose of this paper is to clarify the contribution of nature-based solutions to enhancing urban resilience in post-disaster settings. Resilience has gained significant political traction as a goal of urban environmental governance, and is mentioned in Sustainable Development Goal 11 (UN, 2016); the New Urban Agenda (UN Habitat, 2017); and messaging around the IPCC's Cities initiative (Bai et al, 2018). Meerow et al (2016: 39) define urban resilience as ability to "maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity."

Within urban resilience, nature-based solutions bring environmental, societal and economic benefits towards resilience via the "maintenance, enhancement, and restoration of biodiversity and ecosystems as a means to address multiple concerns simultaneously" (Kabisch et al, 2016: 1). Nature-based solutions in this sense include (but are not limited to) tree planting, establishment or improvement of parks and open spaces, stormwater controls such as retention ponds, restoration of urban rivers, installation of green roofs or rain gardens, and urban agriculture (Keeler et al, 2019). Environmentally, nature-based solutions may build urban resilience through heat mitigation, rainfall retention and runoff reduction, wind shielding, and sustenance of ecosystem health via biodiversity conservation among others (e.g. Beatley, 2014; Gill et al, 2007). Economically, nature-based solutions can free up resources to respond to change by reducing energy consumption or facilitating agriculture, for example (Keeler et al, 2019). Socially, nature-based solutions can enhance ability to cope

with changing conditions by improving physical and mental wellbeing (Pearce et al, 2016) or increasing social cohesion and support networks (Tidball and Aktipis, 2018).

The climate risk reduction benefits of nature-based solutions are recognised in ecosystem-based adaptation (EbA), which refers to the use of ecosystems by people to adapt to change impacts (e.g. Munang et al, 2013). There is also, however, burgeoning interest in the contribution of ecosystem approaches to disasters, through ecosystem-based disaster risk reduction (Eco-DRR). Like EbA, Eco-DRR strives for resilient development through management, conservation and restoration of ecosystems (Estrella and Saalismaa, 2013). This explicit disaster risk focus sets Eco-DRR apart from EbA, which has a climate change focus. Common to both EbA and Eco-DRR, however, is provision of multiple benefits beyond purely disaster risk reduction or climate adaptation (Renaud et al, 2016).

EbA and Eco-DRR are often considered in tandem in scholarly work, given their common interest in deriving multiple benefits from ecosystems towards resilience (e.g. Kabisch et al, 2016; Renaud et al, 2013; Sandholz, 2016). However, in a disaster context, ‘resilience’ may take on a more nuanced definition. Understandings of urban resilience more closely aligned to climate change and sustainability tend to emphasise the ability to maintain core functions and to be better prepared for future events (e.g. Connolly, 2018; Meerow et al, 2016). Yet discussions of resilience in a disaster context also encompasses to the capability of an urban area and the people within it to ‘build back’ in a way that reduces future exposure and takes advantage of post-disaster opportunities (Beatley, 2014). Manyena et al (2011) in fact argue that resilience in a disaster setting entails the ability to ‘bounce forward’ or ‘move on’, putting the emphasis on improvement after disruption as opposed to the maintenance of a steady state. Mannakkara and Wilkinson (2013) too view resilience as something to be

enhanced post-disaster by 'building back better.' In turn, 'building back greener' (Wisner et al, 2015) brings this even closer to nature-based solutions by emphasising how greening actions can be incorporated into disaster recovery as part of creating a more resilient society. Indeed, the post-disaster recovery phase can be a focal point for encouraging integration of ecosystem approaches by governments who may not previously have considered them (Hinzpeter and Sandholz, 2018).

In short, disaster recovery is an opportunity to take stock of how nature-based solutions can help a community to bounce forwards, in a manner that may not have been done previously. Yet compared to extensive research into anticipatory resilience-building for both EbA and Eco-DRR (as in the edited collections of Perez et al, 2010; Renaud et al, 2016), the precise role of nature-based solutions in making disaster-affected urban areas more resilient by 'building back greener' has received more limited empirical attention. Available research illustrates potential of ecosystem approaches to deliver multiple ecological and social benefits in post-disaster recovery, but also shows challenges to realising these benefits. It has been argued in the Indonesian context that flood- and tsunami risk reduction benefits from mangrove restoration have been offset by poor understanding by the government and private sector of the community's own needs (Dalimunthe, 2018). By contrast, studies from both north-east Japan (Takeuchi et al, 2014) and the USA (Tidball, 2014) indicate post-disaster restoration of natural systems can symbolise recovery, support citizens' recovery from loss of traditional and familiar surroundings, and enhance communities' capacity to organise, act and respond to future shocks. In an international synthesis of post-disaster needs assessments, Hinzpeter and Sandholz (2018) argue nature-based approaches may be sidelined in favour of more immediate economic, social and 'hard engineering' infrastructural considerations. Comparative findings from north-east Japan and post-Hurricane Sandy USA suggest limited

integration across local government sectors may also constrain deployment of ecological approaches (Furuta and Shimatani, 2018).

This paper builds on this literature through systematic consideration of how nature-based solutions may enhance urban resilience in an empirical post-disaster context – Futaba County in Fukushima Prefecture, Japan. Specifically, the aims are to (a) clarify the DRR benefits and immediate co-benefits which may be derived from ecosystem approaches in a complex post-disaster setting; (b) understand additional post-disaster urban resilience benefits arising from a wider green infrastructure and the landscape features within it; and (c) utilise the case study to evaluate competences which post-disaster recovery planners might need to realise multiple benefits from nature-based solutions. After Manakkara and Wilkinson (2013), particular attention is paid to post-disaster urban planning as a site for synthesising and understanding the multiple benefits which may be realised from nature-based solutions in 'building back greener.'

1.2. Analytical concepts: green infrastructure and ecosystem services

Two analytical concepts are drawn on to understand how nature-based solutions can help a community 'bounce forwards': green infrastructure and ecosystem services.

Urban green infrastructure can be understood as networks of multifunctional ecological systems within, around and between urban areas across a number of spatial scales; including parks, rain gardens and greenways (Benedict and McMahon, 2002; Meerow and Newell, 2017). Kabisch et al (2016) identify considerable synergy and overlap between 'nature-based solutions', 'green infrastructure' and 'Eco-DRR', as all are concerned with systemic

approaches and concrete implementation actions in response to specific pressures and risks. In DRR, green infrastructure connects Eco-DRR approaches with more traditional engineering, and may encompass post-disaster aspects other than risk reduction (Hinzpeter and Sandholz, 2018). Thinking in terms of green infrastructure also places more explicit emphasis on both the benefits provided by discrete landscape features and their relation to a wider network which can build resilience across an urban area (Dennis et al, 2018). For the purposes of this research, green infrastructure therefore offers heuristic framework for systematically analysing how a wider range of nature-based solutions may fit into post-disaster urban planning, recognising that resilience benefits may come from areas beyond DRR.

In turn, as green infrastructure is by definition multifunctional and works across multiple scales, the concept of ecosystem services is useful to explicitly identify, assess (and work towards measuring) the benefits green infrastructure provides to an urban area (Ahern et al, 2014: 255). The Millennium Ecosystem Assessment (2005) lists four overarching categories of benefits people derive from ecosystems - provisioning, regulating, habitat/supporting, cultural – which can be further broken down into a number of sub-categories as outlined in Section 3 (e.g. TEEB, 2011; du Toit et al, 2018). Furthermore, whilst ecosystem services thinking is integral to understanding the multiple benefits people derive from Eco-DRR initiatives (Triyanti and Chu, 2018), the significance of ecosystem services to urban risk reduction is arguably not well understood (Sandholz, 2016). As such, consideration of the ecosystem services provided by the various elements of a green infrastructure appears an important step towards systematic assessment of the potential post-disaster resilience benefits from nature-based solutions.

For the purposes of this paper, these linked terms are thus understood as follows. *Eco-DRR* refers to actions and landscape features with an explicit disaster risk reduction function. *Green infrastructure* is taken to mean a wider network of landscape features, which may include DRR but also encompasses elements providing other benefits. Lastly, *nature-based solutions* is used as an overarching term to holistically discuss the ways in which ecosystems bring resilience benefits post-disaster, encompassing both Eco-DRR and green infrastructure, and also discrete features as well as the landscape as a whole.

2. Futaba County: background and context

Figure 1: location of Fukushima Prefecture and Futaba County within Japan (adapted from map tiles by Stamen Design, under CC BY 3.0. Data by CartoDB and OpenStreetMap, under ODbL).

Figure 2: municipalities of Futaba County (adapted from map tiles by Stamen Design, under CC BY 3.0. Data by CartoDB and OpenStreetMap, under ODbL).

Futaba County is on the coast of Fukushima Prefecture, Japan (Figure 1). It covers 865 km^2, with the Pacific Ocean to the east and the Abukuma Highlands forested mountains to the west. Futaba County is split into eight administrative units – six townships (Hirono, Naraha, Tomioka, Okuma, Futaba, Namie), and two villages (Kawauchi, Katsurao) (Figure 2). At the time of the 2011 disaster, Futaba County had a population of approximately 74,000 people, mainly in the built-up areas on the flat land adjacent to the Pacific Ocean.

2.1. The Great East Japan Earthquake, Tsunami and Nuclear Disaster

On March 11 2011 a magnitude 9.0 earthquake struck north-east Japan, triggering a large tsunami. 212 people in Futaba County were either killed immediately or remain missing (Fukushima Prefecture, 2016). The earthquake and tsunami also disabled cooling systems at the Fukushima Dai'ichi Nuclear Power Plant, located on the border between Okuma and Futaba Towns. The resulting meltdowns and hydrogen explosions released radiation over the surrounding land and sea. Evacuation orders were issued for all eight municipalities in Futaba County, as well as some beyond. Orders have since been lifted or refined depending on progress in decontamination and understanding of local contamination.

In addition to removing debris from the earthquake and tsunami and rebuilding damaged housing and infrastructure, recovery has entailed decontamination in areas such as Futaba County to manage radioactive matter. Decontamination actions include: removing deposits from roofs and ditches; wiping off roofs and walls; high-pressure washing of hard surfaces; removing fallen leaves and lower branches from gardens, trees and forests; and stripping topsoil from parks and farmland (Ministry of Environment, 2018). Green and open spaces require particular decontamination to restore a safe living environment (defined as annual exposure of less than 20 milliSieverts per year). Forest ecosystems surrounding the urbanised areas of Futaba County are challenging to decontaminate given their size and complexity (Namie Town, 2017; Ministry of Environment, 2018).

2.2. Recovery planning

Although Japan had no overarching law to guide local redevelopment planning after the 2011 triple disaster, the Ministry of Land, Infrastructure and Transport undertook an investigation into recovery patterns. On the basis of this guidance, municipalities developed local recovery

177 plans and prepared budget applications for implementation (Tomita, 2014). Recovery plans
178 support local governments in allocating central government funds for recovery (Shiraki and
179 Murakami, 2014), and lay out actions for post-disaster revitalisation.
180
181 In Futaba County, local recovery planning is led by governments at the township/village
182 level, with support from local recovery planning committees (see below). Although led at the
183 municipal level, plan preparation and revision is informed by plans and guidance from central
184 and prefectural governments on areas such as disaster prevention. National-level
185 Reconstruction Ministry representatives in cases join municipal recovery planning
186 committees as observers (e.g. Naraha Town, 2016). In addition to municipal-led actions, local
187 recovery plans also demarcate across space – and outline steps to put into practice –
188 ecosystem recovery and remediation actions led by the central and/or prefectural
189 governments. Actions managed by the national or prefectural level in this way include
190 decontamination of forests and preparation of 'recovery prayer parks' (Namie Town, 2017).
191 Indeed, coastal forests – a key component of Eco-DRR in Futaba County – are overseen by
192 Fukushima Prefecture and involve both national government and prefectural as well as
193 private land. Local recovery plans formalise municipalities' own expectations for support
194 from the Japanese central government to facilitate recovery. These include requests for
195 technical support on ecosystem management (Katsurao Village, 2012); sustained financial
196 support (Namie Town, 2017); and assistance with 'softer' aspects of recovery such as
197 countering harmful rumours about radiation (Naraha Town, 2016).
198
199 Within the municipalities, recovery plan production is driven by a recovery planning
200 committee, and may be guided by a municipal recovery vision. Committee membership
201 consists of representatives from different municipal government departments, plus relevant

industries (e.g. farming and fisheries), civil society organisations engaged with issues such as social welfare, and citizen representatives. Technical expertise is provided through participation of academics from institutions across Japan, but especially Fukushima University given its geographical proximity.

Although recovery planning is led primarily through the municipality and via formal committee meetings, plans have been informed by more 'bottom up' approaches. Researchers have worked with citizens, civil society and municipal officials to create complementary recovery visions which inform or feed into formal planning processes (e.g. Sato (2017) in Tomioka; Shiraki and Murakami (2014) in Namie). Within formal recovery planning, collaborative workshop-type approaches have been utilised to elucidate municipal officials' and civil society representatives' views towards recovery approaches (Futaba Town, 2016). Citizen opinions have been sought not only through public consultation periods (Naraha Town, 2016) and surveys (Namie Town, 2017), but also through approaches such as interviews with young people (Futaba Town, 2016). More specific to nature-based approaches, citizen input is sought for realisation of plans through involvement in tree-planing for coastal forests, collaborative management of green and open space, and organisation of culturally-meaningful festivals linked to the landscape (Fukushima Prefecture Forests, Forestry and Greening Association, 2014; Naraha Town, 2016).

Local recovery plans thus translate recovery goals into tangible actions across space, and underpin other local government policies such as reconstruction visions and general local plans. The local recovery plan acts as a central document connecting input from techno-scientific experts, the municipal revitalisation vision, 'top down' guidance from national and prefectural levels, and 'bottom up' citizen opinions and participation. All townships produced

a second revitalisation plan with a longer (i.e. 10 year) vision aimed at future revitalisation once the long-term prospects for remediation were better understood (Table 2). As an interface for input from different levels and sectors, local recovery plans are hence a relevant and useful document to understand how and in what ways ecosystems are viewed as helping municipalities in Futaba County to bounce forwards and enhance resilience post-disaster[1].

2.3. Recovery status and challenges

Even after evacuation orders are lifted, returning populations are low (Table 1). This has as much (if not more) to do with the social consequences of prolonged evacuation as it does anxiety over radiation. Educational and medical care facilities require months if not years to re-develop (Bruch et al, 2017). Businesses and associated employment also require time to re-establish post-return (Takagi and Seto, 2017). Revitalisation of agricultural sectors – once important to Futaba County – may take even longer due to precautionary monitoring periods and consumer concern (Mabon and Kawabe, 2016). Previous community relations were weakened by evacuation, and new communities and relationships have formed in the places citizens evacuated to (Yamakawa, 2016). Return hence means breaking new relations to return to a smaller and fragmented community. This low population and challenging environment make it all the more important that resilient communities – and ecosystems able to support them – are developed within revitalisation of Futaba County.

[1] Recovery plans consider earthquake/tsunami/radiation recovery together. This paper assesses the plans' response to all elements of the disaster, considering recovery from different elements holistically (although radiation is the longest-term and most complex).

Table 1: pre-disaster and current populations of Futaba County municipalities (source: Fukushima Prefecture (2019); Futaba Town (2019); Hirono Town (2019); Katsurao Village (2018); Kawauchi Village (2018); Namie Town (2019); Naraha Town (2019); Okuma Town (2019); Tomioka Town (2019)).

Municipality	**Population pre-disaster (11 March 2011)**	**Status**	**Current registered population**	**Current population living in town**
Hirono	5,490	Evacuation order fully lifted March 2012.	4,741 (28 Feb 2019)	4,120 (28 Feb 2019)
Naraha	8,011	Evacuation order fully lifted September 2015.	6,946 (28 Feb 2019)	3,947 (28 Feb 2019)
Tomioka	15,960	Evacuation order lifted for south and west April 2017, ~40% 'difficult to return.'	12,972 (1 Feb 2019)	864 (1 Feb 2019)
Okuma	11,505	Still under evacuation order, new urban core to west planned early 2020s.	10,367 (28 Feb 2019)	0 (28 Feb 2019)
Futaba	7,146	Still under evacuation order, new urban core to west planned early 2020s.	6,005 (28 Feb 2019)	0 (28 Feb 2019)
Namie	21,434	Evacuation order for coastal urbanised area lifted March 2017, rural inland 'difficult to return.'	17,256 (28 Feb 2019)	910 (28 Feb 2019)
Kawauchi	3,038	Evacuation order fully lifted June 2016.	2,713 (1 December 2017)	2,197 (1 December 2017)
Katsurao	1,567	Evacuation order partially lifted September 2015, ~30% 'difficult to return.'	1,428 (1 July 2018)	319 (1 July 2018)

Futaba County suffered significant ecological damage to farmland, forests, watercourses and greenspaces from radioactive contamination. Recovery must therefore be imagined over years if not decades. When combined with continued tsunami and earthquake risk, and the social problems outlined above, Futaba County becomes a hugely complex case of disaster recovery. This need for long-term, coordinated and planned action makes it a useful case

study to assess how opportunities for 'building back greener' may be taken within urban disaster recovery planning.

3.Method

Content analysis was undertaken on the most recent disaster recovery plans produced by the eight municipalities in Futaba County (see Table 2). As per Section 2.2., a municipality's recovery plan is the core document guiding the process of 'building back' both the physical environment and the local community. Recovery plans offer insight into how municipal governments in Futaba County utilise ecosystems and their associated services to build post-disaster resilience, and to balance the range of competing pressures in the recovery process. Content analysis of plans has been utilised elsewhere as a basis for evaluating how municipal governments understand ecosystem service benefits for specific urban areas, for example in Italy (Cortinovis and Geneletti, 2018); and the USA (Woodruff and BenDor, 2016).

Table 2: core documents reviewed for content analysis

Township/village	**Plan assessed**	**Year of publication**
Hirono Town	Hirono Town Recovery Plan (Second Edition)	2014
Naraha Town	Naraha Town Recovery Plan (Second Edition)	2016
Tomioka Town	Tomioka Town Disaster Recovery Plan (Second Edition)	2015
Okuma Town	Okuma Town Second Recovery Plan	2015
Futaba Town	Futaba Town Recovery Urban Plan (Second Edition)	2016
Namie Town	Namie Town Recovery Plan (Second Edition)	2017
Kawauchi Village	Kawauchi Village Recovery Plan	2013
Katsurao Village	Katsurao Village Recovery Plan (First Edition)	2012

Following Dennis et al (2018), the analysis focused on ecosystem services provided by discrete landscape features as green infrastructure elements. This provided deeper understanding of how different landscape features may contribute to social and ecological

resilience. Moreover, for greater analytical insight into how nature-based solutions provide a wider suite of benefits post-disaster beyond DRR, landscape features were analysed in two groups: features with an explicit or main DRR function (e.g. tsunami inundation prevention, landslide mitigation); and features which provide resilience benefits through other ecosystem services not immediately related to disaster risk.

A heuristic coding scheme (Table 3) was developed to identify relevant landscape features in the recovery plans. This was based on the non-exhaustive list of what may be included within urban 'green' infrastructure produced by Foster et al (2011), and was refined and adapted to the Futaba County context through the author's own knowledge of the locale and of the Japanese language. Each plan was read in full, and points where terms relating to landscape features were mentioned were highlighted. Words or phrases not included in the coding guide but representing similar concepts were of course also highlighted if relevant.

Table 3: coding scheme of landscape features, to guide analysis of recovery plans

Category	**Indicative elements (Japanese phrases read for during coding in brackets)**
Agricultural lands	Farmland (農地、農用地) (including rice paddies (水田、畑))
Green and open spaces	Greenspace (緑地); parks (公園); wild vegetation (草)
Rivers and wetlands	Rivers (川、河川); wetlands (湿地、湿原); ponds (ため池); lakes and reservoirs (池湖、ダム)
Forests	Smaller/urban forested areas (林、森、森林); mountainous forests at rural-urban periphery (山林)
Green alleys and streets	Individual/street trees (木) (including cherry blossoms (桜)); street greenery (plants (植物), flowers (花), generic descriptions of greenery (緑、みどり、緑化))

To clarify the ecosystem services considered within each of the plans and in relation to each of the relevant features included within them, the analytical framework of du Toit et al (2018) was adapted. Du Toit et al categorised documents according to urban ecosystem service

297 categories listed in the TEEB framework (TEEB, 2011), grouped into the four overarching
298 categories (provisioning, regulating, habitat/supporting, cultural) listed by the Millennium
299 Ecosystem Assessment (2005) and divided into sub-categories (see Table 4). For additional
300 interpretative depth, statements within the plans relating to specific landscape features were
301 assigned to categories according to the ecosystem services mentioned or implied. Statements
302 could be assigned to more than one category if more than one service was mentioned. For
303 each case, it was also noted whether the ecosystem service was either: currently or
304 imminently being realised; not currently delivering full benefit, but likely to be
305 restored/realised within 5-10 years as a result of clearly-specified actions (e.g. planting trees
306 for coastal forests, completion of scheduled decontamination); or damaged and likely to
307 require significant action over 10+ years to restore (e.g. decontamination of forests,
308 replanting of trees). Lastly, for each ecosystem service mentioned within each plan, it was
309 noted whether (and in what way) the plan attempted to provide assessment of the service in
310 question. The overview of potential indicators provided by de Groot et al (2010) was used as
311 a guide to identify statements in plans indicating an attempt to assess the ecosystem services
312 on the part of the municipal government (Table 4). 'Assessment' of ecosystem services was
313 generally taken to mean a statement of quantitative value, but for cultural services which may
314 not be so readily quantifiable, this was also understood as presence of a qualitative statement
315 of value in relation to specific landscape features or locations.
316
317
318
319
320

321 Table 4: coding scheme of ecosystem services and potential indicators, to guide analysis of

322 recovery plans

Ecosystem service	Ecosystem service sub-category	Exemplar language/terms showing evidence of assessment (adapted from de Groot et al, 2010)
Provisioning	Food	Stock (kg/ha)
	Raw materials	Total mass/area (kg/ha)
	Fresh water	Total amount of water (m^3/ha)
	Medicinal resources	Total amount of useful substances (kg/ha)
Regulating	Local climate and air quality	Amount of chemicals 'extracted'
	Carbon sequestration and storage	Amount of carbon sequestered, area of land cover (e.g. kg/ha/year)
	Moderation of extreme events	Area of land providing moderation (m^3/ha)
	Waste-water treatment	Amount of waste water treated/stored (m^3/kg)
	Erosion prevention and maintenance of soil fertility	Amount of soil retained and/or regenerated (e.g. kg/ha/year)
	Pollination	Number/impact of pollinating species
	Biological control	Number/impact of pest control species
Habitat/ supporting	Species habitats	Number of species and/or individuals
	Maintenance of genetic diversity	Number of endemic species/indicator of natural biodiversity
Cultural	Recreation and mental and physical health	Number/area of landscape features with stated value/appreciation
	Tourism	Number/area of landscape features with stated value/appreciation
	Aesthetic appreciation and inspiration for culture, art and design	Presence of landscape features or species with stated aesthetic and inspirational value; statement of specific cultural events or features
	Spiritual experience and sense of place	Presence of landscape features or species with stated spiritual value; statement of specific events or features providing sense of place

323

Norton (2008) warns that simple and 'objective' evaluation criteria can over-state the quality of a plan or policy if they give the impression a plan is 'good' purely because the plan mentions certain items, without qualitatively assessing the substance of what the plan actually says. This study utilised three safeguards in response. First, recording indicative quotes from the revitalisation plans during analysis, to evidence each mention made of ecosystem services and remind the researcher of the context in which the service was mentioned (see Supplementary Data for full breakdown of extracts). Second, supplementing description of the results with additional contextual information to explain in more depth what exactly the revitalisation plans said about each service and in what context. Third, supporting content analysis with site visits to recovery-related landscape features in Futaba County in summer 2017, to gain contextual understanding of the role of green infrastructure in the locale (see Supplementary Data).

4. Results

Figure 3 summarises all ecosystem services from landscape features mentioned in the disaster recovery plans for the eight municipalities in Futaba County. Seven of eight municipalities list features which are linked to reduction of future disaster risk (Figure 4). However, comparing Figures 3 and 4, only a small proportion of the ecosystem services raised across the plans are explicitly connected to landscape features with a stated Eco-DRR function. Section 4.1. hence evaluates ecosystem services linked with specific Eco-DRR measures, and also the ecosystem services which are implicit in the plans more widely.

348 Figure 3: overview of ecosystem services stated as being derived from landscape features in

349 Futaba County municipal recovery plans

		Hirono Town	Naraha Town	Tomioka Town	Okuma Town	Futaba Town	Namie Town	Kawauchi Village	Katsurao Village
Provisioning	Food								
	Raw materials								
	Fresh water								
	Medicinal resources								
Regulating	Local climate and air quality								
	Carbon sequestration and storage								
	Moderation of extreme events								
	Waste-water treatment								
	Erosion prevention and maintenance of soil fertility								
	Pollination								
	Biological control								
Habitat/ supporting	Species habitats								
	Maintenance of genetic diversity								
Cultural	Recreation and mental and physical health								
	Tourism								
	Aesthetic appreciation and inspiration for culture, art and design								
	Spiritual experience and sense of place								

KEY: Service fully realised or imminent; Service partially realised/mid-term action in process; Service damaged/requires long-term action

350

351

352 Figure 4: overview of ecosystem services linked explicitly to Eco-DRR-related features in

353 Futaba County municipal recovery plans

		Hirono Town	Naraha Town	Tomioka Town	Okuma Town	Futaba Town	Namie Town	Kawauchi Village	Katsurao Village
Provisioning	Food								
	Raw materials								
	Fresh water								
	Medicinal resources								
Regulating	Local climate and air quality								
	Carbon sequestration and storage								
	Moderation of extreme events								
	Waste-water treatment								
	Erosion prevention and maintenance of soil fertility								
	Pollination								
	Biological control								
Habitat/ supporting	Species habitats								
	Maintenance of genetic diversity								
Cultural	Recreation and mental and physical health								
	Tourism								
	Aesthetic appreciation and inspiration for culture, art and design								
	Spiritual experience and sense of place								

KEY: Service fully realised or imminent; Service partially realised/mid-term action in process; Service damaged/requires long-term action

4.1. Ecosystem services by sector

This section surveys the nature and extent of ecosystem services included in recovery plans across the municipalities of Futaba County. Indicative examples are provided where possible. A fuller overview of ecosystem services in relation to specific categories, landscape features and municipalities is provided in Table 5 and the Supplementary Data.

4.1.1. Provisioning services

As an area with large agricultural lands and natural resources outside of the urban cores, *provisioning services* feature strongly in Futaba County's recovery plans. Eco-DRR features are claimed to have provisioning co-benefits through, for example, improved quality of

timber stocks alongside DRR-focused forest management (Katsurao) and better provision of water resources as a result of landslide- and flood risk reduction measures (Naraha, Tomioka, Kawauchi, Katsurao). Provisioning services from wider landscape features not explicitly linked to DRR include food (e.g. gradual restarts of rice production in Naraha and Tomioka) and provision of forest products (which for Naraha, Kawauchi and Katsurao are viewed as potential building material for reconstruction). For food and fresh water, almost all municipalities raise the need for careful management and decontamination before ecosystem services can be fully realised again. There is also thinking around how provisioning services can provide short-term economic benefit to the municipalities while high-value products such as food for human consumption remain impossible due to decontamination and monitoring requirements and/or radiation concerns. This can be seen in, for example, the short-term use of farmland to grow animal feed (Naraha, Tomioka, Futaba).

4.1.2. Regulating services

Regulating services in Futaba County are very closely linked to Eco-DRR features. Moderation of extreme events is realised primarily through coastal forests for tsunami risk reduction, which utilise trees to reduce the force of tsunami water before it reaches settlements inland (Furuta and Seino, 2016). Coastal forests are being planted along the Futaba County coast (see Figure 5). Moderation of extreme events via ecosystems also comes through management of forests and riverine systems, to guard against landslides and flooding respectively (Naraha, Tomioka, Kawauchi). A notable regulating service provided by features not linked to Eco-DRR is biological control in Namie. Management of weeds and vegetation reduces the likelihood of wild boars encroaching on human settlements. Boars have become a

significant source of damage and public concern in Namie since their habitats extended to previously inhabited areas during the evacuation period from 2011-2017 (Itoh, 2018).

Figure 5: disaster prevention coastal forest/greenspace in Hirono Town. Trees intended to grow over several decades and reduce energy/effects of future tsunamis (source: author)

4.1.3. Habitat/supporting

Habitat and supporting services are less prevalent in Futaba County's recovery plans. The only link between Eco-DRR and habitat and supporting services is in Tomioka, where sustainable management of farmland is linked to water retention and ecosystem sustenance. Landscape features not explicitly linked to DRR are mainly considered here in terms of how healthy habitat and supporting services can enable rehabilitation of sustainable agriculture,

and by extension the local economy and sense of identity. For example, rivers are stated as supporting fish in Naraha, Okuma and Namie; and support from the natural environment for animal husbandry is raised in Naraha and Katsurao.

4.1.4. Cultural

Cultural services feature broadly in a locale priding itself on its natural environments. Coastal forests, which have a primary Eco-DRR function, have stated cultural co-benefits in the form of a pleasant environment for walking and recreation; and their role in symbolising revitalisation of the local landscape and the associated sense of place it provides. In Naraha, Tomioka, Okuma, Futaba and Namie, coastal forests are being developed into 'recovery prayer parks' (*fukkou kinen kouen*) with the function of not only reducing disaster risk, but also memorialising the March 2011 disaster and symbolising local recovery.

Cultural services from the landscape more widely are positioned as responding to social barriers to revitalisation (e.g. lack of services for children, damaged social bonds, elderly population). Examples include participation in community greening initiatives to deliver wellbeing to children (Naraha, Tomioka); and the value of open spaces and rehabilitation of cherry trees in building social relations and facilitating intergenerational connectivity (Naraha, Tomioka, Okuma, Namie). Moreover, landscape features are stated to provide inspiration and/or a space for culturally-meaningful activities and festivals, including the holding of the *Arukou-kai* in Naraha's Tenjin Misaki Park in 2015 for the first time in five years (Naraha Town, 2016), and the goal of re-starting cherry blossom festivals in Tomioka (Tomioka Town, 2015). In both Naraha and Namie, the integrity of the natural landscape is

discussed as being key to the Japanese sense of *furusato* ('hometown') and in turn spiritual experience and sense of place.

4.2. Ecosystem services and discrete landscape features

Having surveyed the breadth of ecosystem services considered in the municipalities of Futaba County, this section now evaluates the landscape features mentioned in the recovery plans, and their association with the different ecosystem services. Table 5 lists the features mentioned, and the ecosystem services to which they are related.

Table 5: overview of discrete landscape features associated with ecosystem services, and the municipalities in which they are located

Ecosystem service category	**Ecosystem service sub-category**	**Landscape feature and mentioning townships/ villages**	**Number of cases**
Provisioning	Food	Farmland: Hirono, Naraha, Tomioka, Okuma, Futaba, Namie, Kawauchi, Katsurao	8
		Plants: Okuma, Namie, Katsurao	3
		Rivers: Naraha, Okuma, Namie	3
		Forests at rural-urban periphery: Namie, Katsurao	2
		Individual/street trees: Katsurao	1
	Raw materials	Forests at rural-urban periphery: Hirono, Tomioka, Okuma, Namie, Kawauchi, Katsurao	6
		Individual/street trees: Naraha, Tomioka, Namie, Katsurao	4
		Plants: Hirono, Naraha, Okuma	3
		Rivers: Tomioka, Namie, Katsurao	3
		Farmland: Naraha, Okuma, Futaba	3
	Fresh water	Rivers: Hirono, Naraha, Okuma, Futaba, Namie, Kawauchi, Katsurao	7
		Ponds: Naraha, Tomioka, Futaba, Namie	4
		Forests at rural-urban periphery: Naraha, Futaba, Kawauchi, Katsurao	4
		Farmland: Hirono, Namie	2
		Reservoirs: Tomioka	1

	Medicinal resources	Plants: Okuma	1
Regulating	Local climate and air quality		0
	Carbon sequestration and storage		0
	Moderation of extreme events	Smaller/urban forested areas: Naraha, Tomioka, Futaba, Namie,	4
		Forests at rural-urban periphery: Katsurao	1
		Parks: Naraha, Futaba	2
		Greenspace: Hirono, Futaba	2
		Rivers: Tomioka, Kawauchi	2
		Farmland: Naraha, Tomioka	2
		Wild vegetation: Kawauchi	1
		Individual/street trees: Tomioka	1
		Reservoirs: Tomioka	1
	Waste-water treatment		0
	Erosion prevention and maintenance of soil fertility	Farmland: Namie, Katsurao	2
	Pollination		0
	Biological control	Wild vegetation: Namie	1
Habitat/ supporting	Species habitats	Farmland: Naraha, Tomioka, Katsurao	3
		Rivers: Naraha	1
		Reserviors: Naraha	1
	Maintenance of genetic diversity	Flowering plants: Naraha, Tomioka	2
		Individual/street trees: Tomioka	1
Cultural	Recreation and mental and physical health	Parks: Hirono, Naraha, Tomioka, Okuma, Futaba, Namie, Katsurao	7
		Smaller/urban forested areas: Hirono, Okuma, Namie	3
		Forests at rural-urban periphery: Kawauchi	1
		Farmland: Hirono, Naraha, Katsurao	3
		Flowering plants: Naraha, Tomioka, Futaba	3
		Individual/street trees: Naraha, Tomioka, Futaba	3
		Rivers: Okuma, Namie, Katsurao	3
		Plants: Tomioka, Futaba	2
		Greenspace: Okuma, Futaba	2
	Tourism	Parks: Naraha, Tomioka, Futaba, Namie, Katsurao	5
		Rivers: Naraha, Namie	2
		Forests: Katsurao	1
		Individual/street trees: Tomioka	1

	Aesthetic appreciation and inspiration for culture, art and design	Parks: Naraha, Okuma, Katsurao	3
		Flowering plants: Okuma, Futaba, Namie	3
		Individual/street trees: Naraha, Tomioka	2
		Wild vegetation: Namie	1
		Plants: Futaba	1
		Farmland: Naraha	1
		Rivers: Naraha	1
		Reservoirs: Naraha	1
	Spiritual experience and sense of place	Parks: Naraha, Tomioka, Okuma, Futaba, Namie, Katsurao	6
		Individual/street trees: Naraha, Tomioka, Okuma, Futaba, Kawauchi	5
		Rivers: Naraha, Okuma, Futaba, Namie	4
		Smaller/urban forested areas: Naraha	1
		Forests at rural-urban periphery: Okuma, Kawauchi	2
		Farmland: Naraha	1
		Reservoirs: Naraha	1

Within *provisioning services*, unsurprisingly food is raised most often for farmland, raw materials in relation to forests at the rural-urban periphery (and the trees within them), and rivers for fresh water. Forests at the rural-urban periphery and ponds are also discussed for fresh water, given the role of ponds in providing water for farming and mountain forests as hosting the source for rivers respectively. Within *regulating services*, moderation of extreme events is connected most often to smaller or urban forested areas – specifically, coastal protection forests being planted along the Pacific Coast (and also in inland Katsurao, where forests are mentioned in relation to generic disaster prevention). For *habitat/supporting services*, species habitats are discussed most for farmland. Discussion on genetic diversity is restricted to flowering plants and individual/street trees. For *cultural services*, recreation and physical/mental health is associated most with parks and forested areas, but also in three cases with farmland. Farmland is narrated as being part of citizens' everyday lived landscape (e.g. Hirono Town, 2014; Naraha Town, 2016) and can build social capital and cohesion post-disaster via collaborative community-based farming (see Figure 6 and Takeuchi et al, 2014).

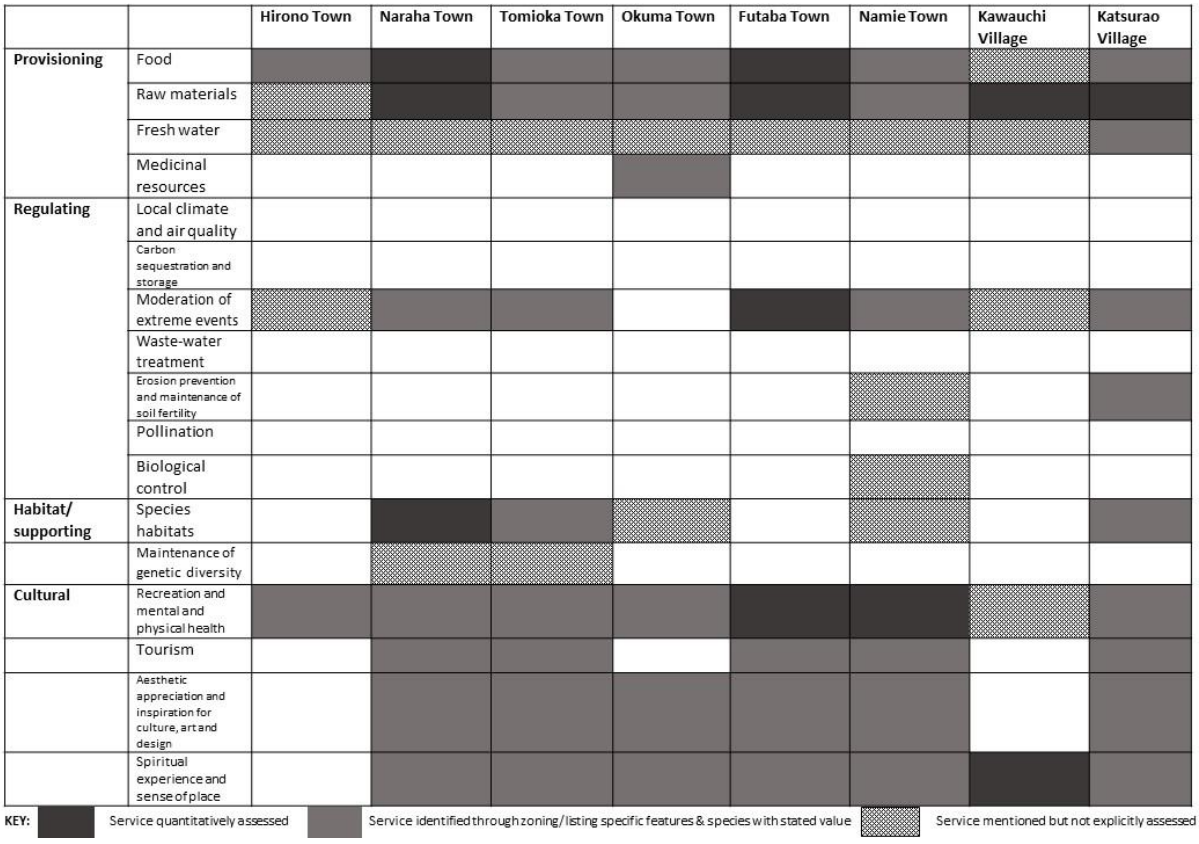
Tourism is raised most for parks and rivers, whereas aesthetic appreciation and inspiration with culture is most often associated with parks, flowering plants and individual/street trees. Spiritual experience and sense of place is most commonly linked to parks. This has much to do with the establishment of ‘recovery prayer parks’ in coastal townships. Also significant, though, is the frequency with which individual/street trees are discussed for spiritual value. As narrated in recovery plans (e.g. Tomioka, Futaba, Namie) this is related to the strength of local pride in cherry blossom trees, and hence the strengthening of identity and sense of place that comes with being able to re-start meaningful activities (such as viewings and festivals) related to cherry blossom.

Figure 6: Kido Citizens’ Rice Field, Naraha Town (source: author)

In post-disaster recovery, different landscape features may hence be associated with different ecosystem services, all of which contribute differently to social and ecological resilience. 'Building back greener' may thus be more effective if it considers not only new or improved landscape features (e.g. Eco-DRR), but also the benefits which are provided by preserving or rehabilitating existing landscape features. However, coordinating a green infrastructure post-disaster requires competence in assessing or planning landscape features across space – as is now evaluated.

4.3. Assessment of ecosystem services

Figure 7: overview of extent to which municipalities in Futaba County attempt to quantify or specify ecosystem services provided by landscape features within recovery plans



Evaluating municipal efforts at ecosystem service assessment is important because although ecosystem services are central to Eco-DRR and green infrastructure (Estrella and Saalismaa, 2013) in practice there may be limited understanding of ecosystems in an urban DRR context (Sandholz, 2016). Figure 7 illustrates the extent to which the recovery plans attempt to assess ecosystem services, or at least identify specific areas/locations associated with the relevant services on a spatial plan (see Supplementary Data for full breakdown of what is assessed/zoned). Assessment of *provisioning* services is limited to calculating areas of land for food, horticulture and biomass (Naraha, Futaba), plus proportion of forest resources (Kawauchi, Katsurao) – although in most municipalities land for farming restarts is zoned. Targets for horticulture area are set (Naraha) and sites for micro-hydro electricity specified (Katsurao). For *regulating*, only Futaba explicitly states the length/area of coastal protection forest, but four other municipalities do demarcate sites for such forests. For *habitat/supporting*, the only assessment comes through targets for livestock set by Naraha. *Cultural* services are assessed in the plans largely through statement of specific features/sites providing recreational, aesthetic/cultural or spiritual value (e.g. Tenjin Misaki Park in Naraha; Takase River Valley in Namie), however three municipalities (Futaba, Namie, Kawauchi) quantify areas of green public space providing value.

Municipal governments in Futaba County appear aware of their limitations to understand and manage the complexities of ecosystems. Katsurao Village (2012) calls for national government support to help the village realise water and disaster prevention benefits from forests post-decontamination. Namie Town (2017) too identifies a need to push for external support and specialist knowledge to help with renewing traditional *satoyama* land management practices in a way that balances pressures such as radiation reduction, forest protection and disaster prevention. In Futaba County, assessment of ecosystem services

511 within recovery plans is hence a challenge. As is now discussed, this can have implications
512 for clarifying the value of landscape features in building resilience.
513
514 5. Discussion
515
516 5.1. Cultural ecosystem services within post-disaster ecosystem approaches
517
518 A notable finding from Futaba County is the breadth of cultural ecosystem services
519 associated with landscape features in the disaster recovery plans. These cultural services may
520 enhance citizen wellbeing, act as spaces for education to enhance preparedness for any future
521 disasters, or rebuild a sense of pride and local identity by symbolising the rehabilitation of the
522 communities more widely.
523
524 On one hand, these findings empirically reinforce and nuance what is already known about
525 how nature-based solutions can build resilient urban societies. Keeler et al (2019: 34) argue
526 that "services provided by urban nature via improved mood and cognitive function will have
527 the greatest net value in cities where stress rates are high and the need for restoration is
528 greatest." Futaba County is very much a stressed area due to the magnitude of the disaster
529 and the difficulties in returning to daily living; and an area where there is a great need for
530 social (not only ecological) restoration due to the damage caused by the tsunami, earthquake
531 and nuclear accident. It is therefore perhaps not surprising that cultural ecosystem services
532 are given such a prominent role – whether consciously or otherwise – in recovery from the
533 2011 disasters. Futaba County also reflects previous research (e.g. Tidball, 2014; Tidball and
534 Aktipis, 2018) emphasising the benefits of post-disaster greening in making communities
535 better connected and able to organise themselves. This is especially significant in Futaba

536 County, where landscape features can become focal points for activities such as festivals
537 which facilitate social connectivity. However, different to previous research in Japan into
538 cultural ecosystem services which focus on the importance of distinct locations and features
539 (e.g. shrines, temples) in helping people to understand cultural ecosystem services
540 (Hashimoto et al, 2015), in Futaba County the health of the landscape as a whole (Kawauchi
541 Village, 2013; Naraha Town, 2016) also forms the basis of wellbeing and pride. Futaba
542 County hence illustrates a role for cultural ecosystem services in 'bouncing forwards.' Yet
543 fuller realisation of these services may necessitate looking to the services provided across the
544 landscape as a whole as well as from discrete projects or features.
545
546 Conversely, cultural ecosystem services have received only limited attention in the literature
547 more specific to Eco-DRR. Post-disaster restart of events such as the *Hamakudari /*
548 *Tantanperopero* festivals in Hirono and Naraha[2], and spring cherry blossom viewing in
549 Tomioka, reflect the argument that cultural practices associated with ecosystems provide
550 coping mechanisms for communities after a disaster has struck (Jiagysu, 2014; Sandholz,
551 2016). The value of ecosystems as a source of resilience by sustaining or reactivating
552 community connectivity goes far beyond the economic (via tourism) and recreational benefits
553 cited as cultural ecosystem services in other Eco-DRR work (e.g. Kaiser et al, 2013; McVittie
554 et al, 2018). This is of course not to say extant Eco-DRR research ignores social and cultural
555 benefits. Rather, the value afforded to spiritual and inspirational benefits in the Futaba
556 recovery plans indicates there may be a need for more explicit attention to cultural ecosystem
557 services within Eco-DRR scholarship alongside the focus on risk reduction. This may be
558 especially so if the goal is to 'build back greener' and make a community more resilient to

[2] Annual festivals in which a small portable shrine is carried from the mountains down to the sea, to bring the energy of the gods to the coastal settlements (Hirono Town, 2011; Naraha Town, 2013).

559 future shocks. However, in Futaba County there are few attempts to assess cultural ecosystem
560 services beyond identifying specific locations and quantifying areas of associated open space.
561 This raises the wider question of how cultural ecosystem services may meaningfully be
562 assessed (Hashimoto et al, 2015; Small et al, 2017) in a way that allows their benefits to be
563 considered alongside potentially more quantifiable risk reduction benefits within technical
564 Eco-DRR approaches. This issue of integration in the planning process feeds into the next
565 discussion point.
566
567 5.2. 'Building back greener' and recovery planning
568
569 The second discussion point concerns how to put 'building back greener' rhetoric into
570 practice. Post-disaster recovery planning represents an opportunity to 'build back better' by
571 integrating resilience-building, Eco-DRR, and wider greening initiatives into urban re-
572 building (Hinzpeter and Sandholz, 2018; Manakkara and Wilkinson, 2013). Futaba County
573 illustrates that 'building back greener' can involve appropriating the recovery planning
574 process to systematically take stock of existing landscape features as part of a green
575 infrastructure, and consider the ecosystem services they provide, in ways that have not been
576 done previously. This is in addition to the development of 'new' nature-based solutions such
577 as coastal forests, and illustrates the value of considering in tandem DRR *and* a much wider
578 suite of resilience benefits provided by nature-based solutions and a green infrastructure
579 across the landscape.
580
581 Nonetheless, the strong focus on cultural services discussed in Section 5.1. raises a wider
582 challenge for 'building back greener.' Namely, how to consider nature-based solutions within
583 recovery planning, in a way that balances a technical approach to provisioning and regulating

584 services with a potentially more holistic consideration of cultural services. This is especially
585 challenging as cultural services may be realised through citizen participation in planning and
586 recovery (e.g. Takeuchi et al, 2014; Tidball and Aktipis, 2018). One approach being trialled
587 in Futaba County which could reconcile these pressures is the *satoyama* land management
588 model. This reflects the call of Sandholz (2016) for reconsidering traditional cultural
589 relationships with ecosystems in the recovery process. *Satoyama* is a traditional Japanese idea
590 of rural agricultural landscape, focusing on the interdependent relationship between humans
591 and the environment they inhabit. *Satoyama* makes links across ecosystem services, and
592 connects ecological and societal benefits (Natuhara, 2013). What is valuable about *satoyama*,
593 given the findings of the Futaba study, is its emphasis on public benefits and in particular
594 cultural ecosystem services. The participatory nature of *satoyama* practice, with citizen and
595 civil society participation in management (Takeuchi, 2010), may further balance technical
596 and participatory approaches.
597
598 Since 2016, model *satoyama* projects have been established in nearly every municipality of
599 Futaba County. It is too early to evaluate the success of such initiatives in balancing a breadth
600 of ecosystem services across the landscape. Yet effective *satoyama* practice requires good
601 techno-scientific competence in assessment of ecosystem service and the management of
602 trade-offs (Indrawan et al, 2014). Whether this is available in a post-disaster context is open
603 to question. Recovery plans, which are a valuable point for synthesising nature-based
604 solutions across space, may be produced and managed under constrained conditions. In
605 Futaba County, local governments and their staff (who are often themselves citizens (Futaba
606 Town, 2018)) were evacuated to municipalities many tens of kilometres away for several
607 years while their hometowns were decontaminated and rehabilitated. Recovery plans were
608 developed remotely by teams of available staff and consulted citizens (Tomioka Town, 2015;

609 Namie Town, 2017). Municipalities in Futaba County have already called for external
610 support to better manage rehabilitation of natural ecosystems (e.g. Katsurao Village, 2012;
611 Namie Town, 2017).
612
613 Understanding traditional cultural relationships with ecosystems such as *satoyama* – and
614 integrating this into recovery planning - may therefore offer a pathway to 'building back
615 greener' in a way that links technical approaches with cultural and participatory aspects.
616 However, there may need to be a significant increase in skills, staffing and financial support
617 from institutions at higher levels overseeing recovery efforts (e.g. national governments) to
618 fully realise the benefits of Eco-DRR and wider ecosystem approaches post-disaster. Futaba
619 County also demonstrates that it may be difficult to acquire these competences in the
620 immediate post-disaster period, when pressing infrastructural concerns can take priority and
621 when local governments may already be overstretched and/or working in compromised
622 conditions.
623
624 5.3. Cautions
625
626 Nature-based solutions and Eco-DRR approaches will not automatically bring post-disaster
627 benefit to citizens at greatest risk of harm (Dalimunthe, 2018). It has also been argued that
628 enhancing resilience ought to be at most an *aid* to recovery (Cho, 2014). The limits to
629 building societal resilience through ecosystem approaches are especially pronounced in
630 Futaba County. Socio-cultural benefits from ecosystem services cannot override the need to
631 rebuild schools, medical facilities and transport links, or to remove harmful radiation, as part
632 of full recovery. These are actions which require sustained and coordinated investment from
633 national government.

Similarly, it is important post-disaster to treat ecosystem services as a heuristic (after Norgaard, 2010) for understanding the breadth of ways in which communities may benefit from 'building back greener,' and not as an absolute indicator of the value of Eco-DRR-type approaches. Cultural services – which the Futaba findings indicate may be important – are challenging to value and integrate with valuations of other services (Small et al, 2017). Moreover, Keeler et al (2019) warn against over-selling the value of nature-based approaches, which may come off second-best to traditional engineering approaches in efficiency or cost terms. This is particularly important in a post-disaster context, where nature-based solutions may be just one type of intervention among many competing for funding and attention. Broader-based arguments for ecosystem approaches, grounded for instance in the symbolic value of landscape features and appeals to local identity, may have a greater chance of gaining political traction than narrow arguments tied tightly to the value of ecosystem services.

6. Conclusion

Futaba County is an extreme case for disaster recovery. The tsunami and earthquake mean coastal urban areas require significant rebuilding, and ecosystem management over decades is required to address radioactive contamination. This need for recovery planning and attention to ecosystems is, however, an opportunity to understand how a community may 'build back greener' through nature-based solutions. The first aim was to clarify the DRR benefits and immediate co-benefits which may be derived from nature-based solutions in a complex post-disaster setting. In Futaba, DRR is a relatively small part of how the landscape is viewed as contributing to a more resilient society post-disaster. Nonetheless, nature-based solutions

have a prominent role in building resilience to future tsunamis, and can simultaneously act as a site for education and memorialisation. The second aim was to understand the post-disaster urban resilience benefits arising from a wider green infrastructure and the landscape features within it. Cultural ecosystem services feature strongly across the landscape in Futaba as a benefit which may help communities to bounce forwards. This has been touched on in some Eco-DRR work to date, but the role of cultural services in facilitating connectivity and symbolising recovery is worth further investigation in other contexts. The third aim was to identify competences which post-disaster recovery planners might require to realise multiple benefits from nature-based solutions. Futaba illustrates that whilst disaster recovery plans can act as a site and opportunity to understand resilience benefits in concert and think of a green infrastructure across a locale, turning this into practice requires significant techno-scientific competence which may not always be available post-disaster. This is true even in a well-resourced country like Japan. Lastly, similar to Futaba County, many localities will not have the opportunity to fully consider resilience benefits from ecosystem approaches in advance of a disaster. More attention to understanding the development of Eco-DRR and green infrastructure in the post-disaster phase may guide locales to 'build back greener' and enhance resilience to future events.

REFERENCES

Ahern J, Cilliers S, Niemela J (2014) 'The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation' *Landscape and Urban Planning* 125: 254-259.

Bai X, Dawson RJ, Urge-Vorsatz D, Delgado GC, Barau AS, Dhakal S, Dodman D, Leonardsen L, Masson-Delmotte V, Roberts D, Schulz S (2018) Six research priorities for cities and climate change *Nature* 555, 23-25.

Beatley T (2014) 'Planning for Resilient Coastal Communities: Emerging Practice and Future Directions' in Glavovic BC, Smith GP (eds) *Adapting to Climate Change* Springer: Dordrecht DOI 10.1007/978-94-017-8631-7_6

Benedict MA and McMahon ET (2002) *Green Infrastructure: Smart Conservation for the 21st Century* Island Press: Washington DC.

Bruch C, Karimi S, Manatunge J, Nakayama M (2017) 'Barriers to Long-Term Return after the Great East Japan Earthquake: Lessons from Hirono Town' *Journal of Asian Development* 3: 24-39.

Cho A (2014) 'Post-tsunami recovery and reconstruction: governance issues and implications of the Great East Japan Earthquake' *Disasters* 38: S157-S178.

Connolly JT (2018) 'From systems thinking to systemic action: social vulnerability and the institutional challenge of urban resilience' *City and Community* 17(1): 8-11.

Cortinovis C and Geneletti D (2018) 'Ecosystem services in urban plans: what is there, and what is still needed for better decisions' *Land Use Policy* 70: 298-312.

Dalimunthe SA (2018) 'Who manages space? Eco-DRR and the local community' *Sustainability* 10(6), 1705; https://doi.org/10.3390/su10061705

Dennis M, Barlow D, Cavan G, Cook P, Gilchrist A, Handley J, James P, Thompson J, Tzoulas K, Wheater P, Lindley S (2018) 'Mapping Urban Green Infrastructure: A Novel Landscape-Based Approach to Incorporating Land Use and Land Cover in the Mapping of Human-Dominated Systems' *Land* DOI: 10.3390/land7010017

The Economics of Ecosystems and Biodiversity (2011) *TEEB Manual for Cities: Ecosystem Services in Urban Management* UFZ: Leipzig.

Estrella M and Saalismaa N (2013) 'Ecosystem-based disaster risk reduction (Eco-DRR): an overview' in Renaud FG, Sudmeier-Rieux K, Estrella M (eds) *The role of ecosystems in disaster risk reduction* UNU Press: Tokyo pp 26–54.

Foster J, Lowe A, Winkelman S (2011*) The Value of Green Infrastructure for Urban Climate Adaptation* Center for Clean Air Policy, Washington DC.

Fukushima Prefecture Forests, Forestry and Greening Association (2014) 'Content of Activities' (in Japanese) http://www.fukushimanomori-kaiganrin.jp/jigyou/jigyou.html, accessed 03/03/2019.

Fukushima Prefecture (2016) *Third ideal plan for recovery prayer parks in Fukushima Prefecture* Fukushima Prefecture: Fukushima City. https://www.pref.fukushima.lg.jp/uploaded/attachment/150621.pdf, accessed 03/03/2019.

Fukushima Prefecture (2019) 'The current status in evacuation order areas' (in Japanese) http://www.pref.fukushima.lg.jp/site/portal/list271-840.html

Furuta N and Seino S (2016) 'Progress and gaps in Eco-DRR policy and implementation after the Great East Japan Earthquake' in Renaud F, Sudmeier-Rieux K, Estrella M, Nehren U (2016) *Ecosystem-Based Disaster Risk Reduction and Adaptation in Practice* Springer: New York pp 295-314.

Furuta N and Shimatani Y (2018) 'Integrating ecological perspectives into engineering practices – perspectives and lessons from Japan' *International Journal of Disaster Risk Reduction* DOI: 10.1016/j.ijdrr.2017.12.003

Futaba Town (2016) *Futaba Town Recovery Urban Plan (Second Edition)* (in Japanese) Futaba Town: Futaba.

Futaba Town (2018) 'The Recovery Plan Number 1: 'What is the Futaba Town Revitalisation Urban Plan (Second Edition)?' (in Japanese) https://www.youtube.com/watch?v=gb-AMOFHmN0, accessed 26/07/2018

Futaba Town (2019) 'Futaba Town' (in Japanese) https://www.town.fukushima-futaba.lg.jp/, accessed 03/03/2019.

Gill SE, Handley JF, Ennos AR, Pauleit S (2007) 'Adapting Cities for Climate Change: The Role of the Green Infrastructure' *Built Environment* 33: 115-133.

de Groot RS, Alkemade R, Braat L, Hein L, Willemen L (2010) 'Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making' *Ecological Complexity* 7: 260-272.

Hashimoto S, Nakamura S, Saito A, Kohsaka R, Kamiyama C, Tomiyoshi M, Kishioka T (2015) 'Mapping and characterizing ecosystem services of social–ecological production landscapes: case study of Noto, Japan' *Sustainability Science* 10: 251-273.

Hinzpeter K and Sandholz S (2018) 'Squaring the circle? Integrating environment, infrastructure and risk reduction in Post Disaster Needs Assessments' *International Journal of Disaster Risk Reduction* DOI: 10.1016/j.ijdrr.2018.05.016

Hirono Town (2013) 'Hamakudari Shinji: Otaki Shrine / Kashima Shrine Festival' (in Japanese) https://www.town.hirono.fukushima.jp/sangyo/hamakudari_shinji.html, accessed 04/03/2019.

Hirono Town (2014) *Hirono Town Recovery Plan (Second Edition)* (in Japanese) Hirono Town: Hirono.

Hirono Town (2019) 'Hirono Town' (in Japanese) http://www.town.hirono.fukushima.jp/, accessed 03/03/2019.

Indrawan M, Yabe M, Nomura H, Harrison R (2014) 'Deconstructing satoyama: the socio-ecological landscape in Japan' *Ecological Engineering* 64: 77-84.

Itoh M (2018) *Animals and the Fukushima Nuclear Disaster* Springer: New York.

Jigyasu R (2014) ‘Fostering resilience: towards reducing disaster risks to World Heritage’ *World Heritage* 74: 4–13.

Kabisch N, Frantzeskaki N, Pauleit S, Naumann S, Davis M, Artmann M, Haase D, Knapp S, Korn H, Stadler J, Zaunberger K, Bonn A (2016) ‘Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action’ *Ecology and Society* DOI: 10.5751/ES-08373-210239

Kaiser G, Burkhard B, Romer H, Sangkaew S, Graterol R, Haitook T, Sterr H, Sakuna-Schwartz D (2013) ‘Mapping tsunami impacts on land cover and related ecosystem service supply in Phang Nga, Thailand’ *Nat. Hazards Earth Syst. Sci.* 13: 3095–3111

Katsurao Village (2012) *Katsurao Village Recovery Plan (First Edition)* (in Japanese) Katsurao Village: Katsurao.

Katsurao Village (2018) ‘Situation of evacuees from Katsurao Village’ (in Japanese) http://www.katsurao.org/soshiki/2/hinan20180701.html, accessed 26/07/2018

Kawauchi Village (2013) *Kawauchi Village Recovery Plan* (in Japanese) Kawauchi Village: Kawauchi.

Kawauchi Village (2018) ‘Land and population’ (in Japanese) http://www.kawauchimura.jp/page/page000073.html, accessed 03/03/2019.

Keeler B et al (2019) ‘Social-ecological and technological factors moderate the value of urban nature’ *Nature Sustainability* 2: 29-38.

Mabon, L and Kawabe, M (2016) ‘Engagement on risk and uncertainty – lessons from coastal regions of Fukushima Prefecture, Japan after the 2011 nuclear disaster?’ *Journal of Risk Research* DOI: 10.1080/13669877.2016.1200658

Mannakkara S and Wilkinson S (2013) ‘Build Back Better principles for post‐disaster structural improvements’ *Structural Survey* 31: 314-327.

Manyena B, O’Brien G, O’Keeffe P, Rose J (2011) ‘Disaster resilience: a bounce back or bounce forward ability?’ *Local Environment* 16 (5): 417-424.

McVittie A, Cole L, Wreford A, Sgobbi A, Yordi B (2018) ‘Ecosystem-based solutions for disaster risk reduction: Lessons from European applications of ecosystem-based adaptation measures’ *International Journal of Disaster Risk Reduction* 32: 42-54.

Meerow S, Newell JP, Stults M (2016) ‘Defining urban resilience: a review’ *Landscape and Urban Planning* 147: 38-49.

Meerow S and Newell J (2017) 'Spatial planning for multifunctional green infrastructure: Growing resilience in Detroit' *Landscape and Urban Planning* 159: 62-75.

Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis* Island Press: Washington, DC.

Ministry of Environment (2018) *Environmental Remediation in Japan* Ministry of Environment: Tokyo http://josen.env.go.jp/en/pdf/progressseet_progress_on_cleanup_efforts.pdf, accessed 03/03/2019.

Munang R, Thiaw I, Alverson K, Mumba M, Liu J, Rivington M (2013) "Climate change and Ecosystem-based Adaptation: a new pragmatic approach to buffering climate change impacts" *Current Opinion in Environmental Sustainability* 5(1): 67-71.

Namie Town (2017) *Namie Town Recovery Plan (Second Edition)* (in Japanese) Namie Town: Namie.

Namie Town (2019) 'Namie Town' (in Japanese) http://www.town.namie.fukushima.jp/, accessed 03/03/2019.

Naraha Town (2013) 'Spring Festival in Naraha Town: Hamakudari at Omutaki Shrine' https://ameblo.jp/naraha7700/entry-11521105869.html, accessed 04/03/2019.

Naraha Town (2016) *Naraha Town Recovery Plan (Second Edition)* (in Japanese) Naraha Town: Naraha.

Naraha Town (2019) 'On the number of residents in Naraha Town' (in Japanese) http://www.town.naraha.lg.jp/information/info/001469.html, accessed 03/03/2019.

Natuhara Y (2013) 'Ecosystem services by paddy fields as substitutes of natural wetlands in Japan' *Ecological Engineering* 56: 97-106.

Norgaard R (2010) 'Ecosystem services: From eye-opening metaphor to complexity blinder' *Ecological Economics* 69: 1219-1227.

Norton RK (2008) 'Using content analysis to evaluate local master plans and zoning codes' *Land Use Policy* 25: 432-454.

Okuma Town (2015) *Okuma Town Second Recovery Plan* (in Japanese) Okuma Town: Okuma.

Okuma Town (2019) 'Damage and evacuation situation of Okuma Town' (in Japanese) http://www.town.okuma.fukushima.jp/soshiki/jumin/1007.html, accessed 03/03/2019.

Pearce J, Shortt N, Rind E, Mitchell R (2016) ‘Life course, green space and health: incorporating place into life course epidemiology’ *International Journal of Environmental Research and Public Health* 13: 331.

Perez A, Hernandez B, Gatti R (2010) *Building Resilience to Climate Change: Ecosystem-based Adaptation and Lessons from the Field* IUCN: Gland.

Renaud FG, Sudmeier-Rieux K, Estrella M (2013) *The role of ecosystems in disaster risk reduction* UNU Press: Tokyo.

Renaud F, Sudmeier-Rieux K, Estrella M, Nehren U (2016) *Ecosystem-Based Disaster Risk Reduction and Adaptation in Practice* Springer: New York.

Sandholz S (2016) ‘Potential for Ecosystem-Based Disaster Risk Reduction and Climate Change Adaptation in the Urban Landscape of Kathmandu Valley, Nepal’ in Renaud F, Sudmeier-Rieux K, Estrella M, Nehren U (eds) (2016) *Ecosystem-Based Disaster Risk Reduction and Adaptation in Practice* Springer: New York pp335-360.

Sato A (2017) ‘The Structure of Problems Surrounding the Fukushima Nuclear Accident Evacuees’ *Journal of Asian Development* 3: 12-22.

Shiraki R and Murakami K (2014) ‘Towards a “network community” for the displaced town of Namie, Fukushima’ *Planning Theory and Practice* 15(2): 250-255.

Small M, Munday M, Durance I (2017) ‘The challenge of valuing ecosystem services that have no material benefits’ *Global Environmental Change* 44: 57-67.

Sugiyama N and Takeuchi T (2008) ‘Local policies for climate change in Japan’ *The Journal of Environment and Development* 17: 424-441.

Takagi A and Seto M (2017) ‘Bringing businesses back, bringing residents back: efforts and challenges to restore commerce in formerly evacuated areas’ in Yamakawa M and Yamamoto D (eds) *Rebuilding Fukushima* Routledge: London pp130-145.

Takeuchi K (2010) ‘Rebuilding the relationship between people and nature: the Satoyama Initiative’ *Ecological Research* 25: 891-897.

Takeuchi K, Elmqvist T, Hatakeyama M, Kauffman J, Turner N, Zhou D (2014) ‘Using sustainability science to analyse social–ecological restoration in NE Japan after the great earthquake and tsunami of 2011’ *Sustainability Science* 9: 513-526.

Tidball K (2014) ‘Seeing the forest for the trees hybridity and social-ecological symbols, rituals and resilience in post-disaster contexts’ *Ecology and Society* 19 DOI: 10.5751/ES-06903-190425

Tidball K and Atkipis A (2018) ‘Feedback enhances greening during disaster recovery: A model of social and ecological processes in neighborhood scale investment’ *Urban Forestry and Urban Greening* 34: 269-280.

du Toit M, Cilliers S, Dallimer M, Goddard M, Guenat S, Cornelius S (2018) ‘Urban green infrastructure and ecosystem services in sub-Saharan Africa’ *Landscape and Urban Planning* DOI: 10.1016/j.landurbplan.2018.06.001

Tomioka Town (2015) *Tomioka Town Disaster Recovery Plan (Second Edition)* (in Japanese) Tomioka Town: Tomioka.

Tomioka Town (2019) ‘Evacuation inside and outside the prefecture · Number of people by residence’ (in Japanese) http://www.tomioka-town.jp/soshiki/jumin/jumin/hinansya_ninzu/2322.html, accessed 03/03/2019.

Tomita H (2014) ‘Reconstruction of tsunami-devastated fishing villages in the Tohoku region of Japan and the challenges for planning’ *Planning Theory and Practice* 242-246.

Tryianti A and Chu E (2019) ‘A survey of governance approaches to ecosystem-based disaster risk reduction: Current gaps and future directions’ *International Journal of Disaster Risk Reduction* 32: 11-21.

United Nations (2016) ‘Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable’ https://unstats.un.org/sdgs/report/2016/goal-11/, accessed 03/03/2019.

UN Habitat (2017) *New Urban Agenda* United Nations: Nairobi.

Wisner B, Pelling M, Mascarenhas A, Holloway A, Ndong B, Faye P, Robit J, Simon D (2015) ‘Small Cities and Towns in Africa: Insights into Adaptation Challenges and Potentials’ in Pauleit S, Coly, A., Fohlmeister, S., Gasparini, P., Jørgensen, G., Kabisch, S., Kombe, W.J., Lindley, S., Simonis, I., and Yeshitela, K. (eds) *Urban Vulnerability and Climate Change in Africa* Springer: New York DOI 10.1007/978-3-319-03982-4_5

Woodruff S and BenDor T (2016) ‘Ecosystem services in urban planning: Comparative paradigms and guidelines for high quality plans’ *Landscape and Urban Planning* 152: 90-100.

Yamakawa M (2016) ‘Living in suspension: conditions and prospects of evacuees from the eight municipalities of Futaba District’ in Yamakawa M and Yamamoto D (eds) *Unraveling the Fukushima Disaster* Routledge: London.

ENHANCING POST-DISASTER RESILIENCE BY 'BUILDING BACK GREENER': EVALUATING THE CONTRIBUTION OF NATURE-BASED SOLUTIONS TO RECOVERY PLANNING IN FUTABA COUNTY, FUKUSHIMA PREFECTURE, JAPAN

SUPPLEMENTARY DATA 1: MATERIAL FROM SITE VISITS, JUNE 2017

Site visits to recovery-related landscape features in Futaba County were undertaken in summer 2017, to gain contextual understanding of the role of green infrastructure in the locale. In keeping with recognised social science practice (Blomberg et al, 1993), descriptive observations from the site visits were recorded via note-taking and photography (see below). Site visits were conducted to the locations outlined in Table S1.

Table S1: site visit locations in Futaba County

Site/component visited	**Purpose/function**	**Location**
Hirono Disaster Prevention Greenspace	Tsunami risk reduction	Hirono
J-Village	Sports and recreation	Hirono/Naraha
Kido Citizens' Rice Field	Food provision/ building social relations	Naraha
Tenjin Misaki Park Tsunami Disaster Prevention Viewpoint	Tsunami risk reduction/ education/ disaster memorialisation	Naraha
Yonomori Cherry Tree Tunnel	Aesthetic benefit/ source of local pride and identity	Tomioka
Farmland converted to mega-solar	Farming/ energy	Okuma
Public information point	Education and public awareness	Futaba
Namie town centre (urban greening and also remaining weeds/wild growth)	Aesthetic benefit/ symbolisation of revitalisation	Namie

Coastal protection forest, Hirono Town (source: author)

Disaster information viewpoint and view towards Kido area, Tenjin Misaki Park, Naraha Town (source: author)

Yonomori Cherry Tree Tunnel, Tomioka Town (source: author)

Farmland converted to mega-solar electricity production, Okuma Town (source: author)

Rehabilitation of the lived environment through greening, Namie Town Hall (source: author)

Wild/overgrown vegetation management challenges, Namie Town (source: author)

SUPPLEMENTARY DATA 2: FULL OVERVIEW OF ECOSYSTEM SERVICES IN FUTABA COUNTY MUNICIPAL RECOVERY PLANS BY CATEGORY, SUB-CATEGORY AND MUNICIPALITY

Table S2: provisioning services by type and municipality (*italic* = co-benefit of Eco-DRR feature)

Provisioning	Food	Farmland and farm produce: Hirono, *Naraha*, *Tomioka*, Okuma, Futaba, Namie, Kawauchi, Katsurao
		Fish: Naraha, Okuma, Namie
		Animal feed: Naraha, Tomioka, Futaba,
		Mushrooms: Katsurao
	Raw materials	Timber and forest products: Hirono, Tomioka, Okuma, Namie, Katsurao
		Biomass/fuel: Hirono, Naraha, Tomioka, Okuma, Futaba, Namie, Kawauchi, Katsurao
		Housing materials: Naraha, Kawauchi, Katsurao
		Non-consumable products: Okuma
		Hydro electricity generation: Katsurao
	Fresh water	Fresh water: Hirono, *Naraha*, *Tomioka*, Okuma, Futaba, Namie, *Kawauchi, Katsurao*
	Medicinal resources	Aromatic herbs: Okuma

Table S3: regulating services by type and municipality (*italic* = co-benefit of Eco-DRR feature)

Regulating	Local climate and air quality	
	Carbon sequestration and storage	
	Moderation of extreme events	Tsunami inundation reduction: *Hirono, Naraha, Tomioka, Futaba, Namie*
		Flood/runoff reduction: *Naraha, Tomioka, Kawauchi*
		Landslide risk reduction: *Naraha, Tomioka*
		Unspecified disaster risk reduction: *Katsurao*
	Waste-water treatment	

	Erosion prevention and maintenance of soil fertility	Maintenance of soil fertility: Namie, Katsurao
	Pollination	
	Biological control	Reduce damage from wild boars: Namie

Table S4: habitat/supporting services by type and municipality (*italic* = co-benefit of Eco-DRR feature)

Habitat/ supporting	Species habitats	Environment for river fish: Naraha, Okuma, Namie
		Sustenance of ecosystem: *Tomioka*
		Sustenance for animal husbandry: Naraha, Katsurao
	Maintenance of genetic diversity	Diversity and abundance of flora and greenery: Naraha, Tomioka

Table S5: cultural services by type and municipality (*italic* = co-benefit of Eco-DRR feature)

Cultural	Recreation and mental and physical health	Sports and recreation: Hirono, Naraha, *Tomioka*, Okuma, *Futaba*
		Social education: Hirono, Naraha, Okuma, Namie
		General contribution to quality of living environment/public good: Hirono, Naraha, Okuma, Futaba, Katsurao
		Safety and reassurance: Hirono, Namie, Kawauchi
		Maintaining/building social relations: Naraha, Tomioka, Okuma, Namie
		Health and wellbeing for children: Naraha, Tomioka
		Disaster evacuation site: Naraha, Tomioka, Okuma, Katsurao
		Source of pride in environment: Tomioka, Namie
		Intergenerational connectivity: Tomioka
		Source of wellbeing: Okuma
	Tourism	General nature: Naraha
		Trees: Naraha, Tomioka

		Park: Naraha, Tomioka, Futaba, Namie, Katsurao
		River: Naraha, Namie
		Forest: Katsurao
	Aesthetic appreciation and inspiration for culture, art and design	Aesthetic quality of landscape: *Naraha*, Tomioka, Okuma, Futaba, Namie
		Site for culturally meaningful festivals: Naraha, Tomioka, Okuma, Katsurao
	Spiritual experience and sense of place	Sense of 'hometown': Naraha, Namie
		Source of local pride and identity: Naraha, Tomioka, Futaba, Namie
		Sites of historical or religious significance: *Naraha*, Tomioka, Katsurao
		Disaster/recovery memorialisation: Naraha, Tomioka, Okuma, *Futaba*, Namie
		Symbolisation of recovery: Naraha, *Tomioka*, Okuma, Futaba
		Peace from nature: Okuma, Kawauchi

SUPPLEMENTARY DATA 3: FULL OVERVIEW OF ASSESSMENT OF ECOSYSTEM SERVICES WITHIN FUTABA COUNTY MUNICIPAL REVITALISATION PLANS

		Hirono Town	Naraha Town	Tomioka Town	Okuma Town	Futaba Town	Namie Town	Kawauchi Village	Katsurao Village
Provisioning	Food	Farming restart area zoned on revitalisation plan	**Usable farmland area calculated (700ha) Rice cultivation targets set (2 years 60ha, 5 years 200ha, 10 years 300 ha)**	Farming restart area zoned on revitalisation plan	Farming restart area zoned on revitalisation plan	**Usable farmland area calculated 25ha**	Farming restart area zoned on revitalisation plan		Farming restart area zoned on revitalisation plan
	Raw materials		**Horticulture target set (5 years 3ha, 10 years 5ha)**	Forested area zoned on revitalisation plan	Area for new non-food cultivation zoned on revitalisation plan	**Biomass area calculated 8ha**	Forested area zoned on revitalisation plan	**Forested area providing resources calculated (90%)**	**Forested area calculated (80%) Potential micro hydro sites calculated (3-4)**
	Fresh water								Area for water resources zoned on revitalisation plan
	Medicinal resources				Area for new non-food cultivation zoned on revitalisation plan				
Regulating	Local climate and air quality								
	Carbon sequestration and storage								
	Moderation of extreme events		Area for disaster-reduction forest zoned on revitalisation plan	Area for disaster-reduction forest zoned on revitalisation plan		**Length of disaster-reduction forest stated (200m)**	Area for disaster-reduction forest zoned on revitalisation plan		Forested area zoned on revitalisation plan
	Waste-water treatment								
	Erosion prevention and maintenance of soil fertility								Farming restart area zoned on revitalisation plan
	Pollination								
	Biological control								
Habitat/ supporting	Species habitats		**Livestock targets set (5 years 50 animals; 10 years 100 animals)**	Area for planting diverse trees stated in revitalisation plan					Area for animal husbandry zoned on revitalisation plan
	Maintenance of genetic diversity								
Cultural	Recreation and mental and physical health	Area for improving lived environment zoned on revitalisation plan	Features with stated value (Tenjin Misaki Park, Tatsuta Eki-Mae)	Features with stated value (Yonomori cherry trees, Nishihara cherry trees, Revitalisation Memorial Park) Species with stated value (azalea, magnolia, camellia)	Features with stated value (Revitalisation Memorial Park)	**Public space area calculated (11ha)** Features with staved value (Revitalisation Memorial Park; Maeda River) Species with staved value (cherry trees)	**Open space area (Memorial Park) calculated (50ha)** Features with stated value (Revitalisation Memorial Park)		Area for recreation zoned on revitalisation plan
	Tourism		Features with stated value (Kido River Valley, Tenjin Misaki Park)	Features with stated value (Revitalisation Memorial Park, Yonomori cherry trees, Yonomori Park) Species with stated value (cherry trees)		Features with stated value (Revitalisation Memorial Park)	Features with stated value (Revitalisation Memorial Park, Ukedo Port, Takase River Valley)		Features with stated tourism value (Mori Mori Land Forest Park)
	Aesthetic appreciation and inspiration for culture, art and design		Features with stated value (Tenjin Misaki Park, Kido Dam, Kido River) Species with stated value (salmon, trout, cherry tree)	Features with stated value (Yonomori cherry trees, Yonomori Park) Species with stated value (cherry trees)	Areas for facilitating events and for landscaping zoned on revitalisation plan	Features with stated value (Flower Road, Maeda River) Species with stated value (cherry trees)	Features with stated value (Flower Road, Revitalisation Memorial Park, Port, Central Namie)		Features with stated value (Katsurao Daijin-ya Ruins Park)
	Spiritual experience and sense of place		Features with stated sense of place (Tenjin Misaki Park, Kido Dam, Kido River, Memorial Park, Tree of Hope) Species with stated sense of place (salmon, trout) Presence of spiritual value in landscape (sense of history from farmland)	Features with stated sense of place (Revitalisation Memorial Park) Species with stated sense of place (cherry tree, azalea) Presence of spiritual value in landscape (Buddhist statues in parks)	Features with stated sense of place (Revitalisation Memorial Park)	Features with stated sense of place (Revitalisation Memorial Park, Maeda River)	Open space area calculated Features with stated sense of place (Revitalisation Memorial Park) Presence of spiritual value in landscape (sense of hometown from farmland, rivers, mountains)	**Forested area providing sense of place calculated (90%)**	Features with stated sense of place (History Park)

SUPPLEMENTARY DATA 4: INDICATIVE EXTRACTS FROM FUTABA COUNTY REVITALISATION PLANS

HIRONO
http://www.town.hirono.fukushima.jp/data/open/cnt/3/1223/1/fukkokeikaku_dai2ji_kakuteiban.pdf, accessed 23/03/2019

Ecosystem service type	**Ecosystem service sub-category**	**Specific benefit and indicative quote**	**Landscape feature**
Provisioning	Food	Restart of farming: "We will strive to restore agricultural land and make effective use of idle farmland etc." (p22) Plants and food growing as new industry: "High value-added agriculture through establishment of new agriculture such as plant factory" (p27)	Farmland
	Raw materials	Forestry: "Revitalisation of agriculture and forestry" (p15) Plants and food growing as new industry: "High value-added agriculture through establishment of new agriculture such as plant factory" (p27) Energy via biomass: "Biomass: refers to resources derived from organisms such as animals and plants. Above all, biomass is a resource that generates biomass energy, which is one kind of renewable energy." (p34)	Forests at rural-urban periphery Plants
	Fresh water	Fresh water for farming: "We will restore agricultural land and agricultural production infrastructure (lifting / draining machine site, agricultural waterway etc.) etc. and recover agricultural land · agricultural production infrastructure etc. to resume farm management." (p22) Fresh water for living: "Lifestyle related infrastructure, restoration of lifeline and improvement of infrastructure resistant to disasters. We will restore roads, rivers, water supply and sewer, etc." (p21)	Farmland River
	Medicinal resources		
Regulating	Local climate and air quality		
	Carbon sequestration and storage		
	Moderation of extreme events	Coastal disaster risk reduction: "In order to protect human life and property from future assumed tsunamis etc., we aim to defend the new urban area	Greenspace

		of the reconstruction zone by raising the coastal tide shield and the Hirono/Odaka line of prefectural highways (high embankment structure) and disaster prevention green space." (p11) Disaster prevention greenspace" Preparation of tide breakwater, disaster prevention green space" (p38)	
	Waste-water treatment		
	Erosion prevention and maintenance of soil fertility		
	Pollination		
	Biological control		
Habitat/ supporting	Species habitats		
	Maintenance of genetic diversity		
Cultural	Recreation and mental and physical health	Recreation: "Regarding parks and social education/physical education facilities that have become unusable, we will continue to develop for resumption" (p20) Social Education: "Regarding parks and social education/physical education facilities that have become unusable, we will continue to develop for resumption" (p20) Contribution to daily living environment: "Specifically, decontamination is promoted by giving priority to public facilities that many townspeople use, including the educational facilities used by children, and the road shoulder of roads, privately owned facilities, farmland / forest (living area), living area road. We will decontaminate the range of 20 m from the site, vacant lot, wilderness, hybrid area etc" (p17) Reassurance and safety through proper management: Establishment of decontamination technology, and secure and safe agriculture and forestry formation (p27)	Park Forests at rural-urban periphery Farmland
	Tourism		

	Aesthetic appreciation and inspiration for culture, art and design		
	Spiritual experience and sense of place		

NARAHA

http://www.town.naraha.lg.jp/information/files/28.5.9%E5%BE%A9%E8%88%88%E8%A8%88%E7%94%BB%EF%BC%88%E6%9C%AC%E7%B7%A8%EF%BC%89.pdf, accessed 23/03/2019

Provisioning	Food	Restart/rejuvenation of farming: "Preparation for the establishment of agricultural cooperatives etc → In order to prevent devastation of agricultural land, we aim to construct a system that can establish a new agricultural corporation in cooperation with JA etc., and can safely look after farmland" (p27) Restart/rejuvenation of river fishing: "Based on investigation up until now of the influence of radioactive substances on salmon and sweetfish inhabiting and living in the Kido River, revitalisation of agricultural, forestry and fishery processing facilities (such as aquaculture facility and processing facility) occurred. In April 2015, it was possible to undertake juvenile discharge of salmon fish for the first time in five years" (p53) Animal food: "Growing rice for animal consumption (2 years, 60Ha)" (p27)	Farmland River
	Raw materials	Provision of biomass: "We will promote early agriculture resumption by switching crops to rape blossoms etc. that will become fuel for biomass and will lead to farmland conservation and a worthwhile livelihood for farmers" (p52) Energy resource: "As interest in renewable energy increases, we will explore technology development and introduction aiming at local production of energy by utilizing abundant water resources and wood resources in the town" (p54) Material for housing: "Seismic diagnosis and earthquake repair support for privately-owned wooden houses" (p101)	Plant matter Farmland Individual/street trees
	Fresh water	Preserve water resources: "Forest maintenance based on water source recharge, sediment-related disaster prevention etc." (p71) Preserve water quality: "The forest spreading to the west side of the town plays an important role of preventing the outflow of sediment, and is a source of a river that provides rich water to the town, but due to the disaster it was	Forests at rural-urban periphery River

		contaminated with radioactive material. To develop a town which is strong against disasters, and also to protect the water which we enjoy, efforts will be made to look after and protect the town's forests for the next generation" (p75) Water resources: "We regularly and periodically monitor rivers and groundwater related to water supply and sewerage systems" (p107)	
	Medicinal resources		
Regulating	Local climate and air quality		
	Carbon sequestration and storage		
	Moderation of extreme events	Tsunami prevention forest and runoff area: "From now on, through preparation of sea walls with gentle slope method and bulking of prefectural highways for two-way bank maintenance, preparation of coastal forests, and marking out the edges of the tsunami inundation area with poles, from Tenjin Misaki Park we can see in one view the tsunami countermeasures for the next generation" (p62) Runoff reduction: "The agricultural land that has been built up by our ancestors is not just a place for agricultural produce, but also plays many important roles such as an idyllic country landscape, water retention etc. While paying attention to preserving these, we will make effective use of farmland" (p13) Reduce landslide risk: "Forest maintenance based on water source recharge, sediment-related disaster prevention etc." (p71)	Forests at rural-urban periphery Smaller/urban forested areas Park Farmland
	Waste-water treatment		
	Erosion prevention and maintenance of soil fertility		
	Pollination		

	Biological control		
Habitat/ supporting	Species habitats	Environment for river fish: “For Kido Dam and Kido River Valley, decontamination and repair of the pathways is carried out. From now on, we will promote resumption of not only salmon but also sweetfish, and prepare an environment in the Kido River watershed for the catch and release of rockfish and female fish. We will use the rich natural environment with which we are blessed to work to restart tourism, and return to the landscape of hometown Naraha.” (p62) Animal husbandry: “Demonstration animal husbandry → commencement of animal husbandry (50 animals within 5 years)” (p27)	River Reservoir
	Maintenance of genetic diversity	Diversity and abundance of flora and greenery: “Starting with the safety of school routes and removal/seismic reinforcement of fences taking into consideration the local landscape and townscape, to promote greening and creation of an ideal living environment, ‘Creating a Town With Plenty Flowers and Green’ (Project of Hope) as described later will proceed with cooperation” (p104)	Flower
Cultural	Recreation and mental and physical health	Maintaining/rebuilding social relations: “We will utilize wide areas of farmland, including cultivated abandoned land, to create a "Citizens’ Farm" and provide opportunities for residents and regular visitors from outside the town with the opportunity to connect with the soil” (p63) Maintaining/rebuilding social relations: “With human resources, knowledge and activity funds collected from all over the country to help the revitalisation of Naraha, and with the objective of contributing to the revitalisation of the town and the restart of people’s lives, ‘Naraha Supporters’ was created in the town creation organisation ‘Naraha Future’.” (p56) Quality of life for returning citizens: “In addition, we will promote the creation of a town full of flowers by setting up a "flower pride" corner in the town magazine, introducing the flowers which returning residents have grown in their gardens and so on” (p63)	Farmland Flower Individual/street trees Park

		Maintaining relations with still-evacuated citizens: “As for flowers and seedlings, as well as calling for cooperation nationwide, we will request residents living in evacuation to undertake cultivation and make it a motivation.” (p114) General quality of life: “In order to provide a liveable inhabited environment, using the environment of the area in front of Tatsuta Station as a model area of surface maintenance centered around empty lots, we will explore the possibility of improving infrastructure facilities such as parks.” (p19) Quality of life and wellbeing: “Starting with the safety of school routes and removal/seismic reinforcement of fences taking into consideration the local landscape and townscape, to promote greening and creation of an ideal living environment, ‘Creating a Town With Plenty Flowers and Green’ (Project of Hope) as described later will proceed with cooperation” (p104) Health and well-being for children: “Development of a park and a playground where children can play freely” (p37) Health and well-being for children: “The ‘Flowers and Greenery Project’ happened with the participation of children too” (p57) Disaster preparedness and education: “Provide ‘Tsunami disaster prevention measures view point’ at Tenjin Misaki Park” (p60) Disaster preparedness and education: ① Tenjin Misaki Park ‘Tsunami Disaster Prevention Measures View Point" Provision: From now on, through preparation of sea walls with gentle slope method and bulking of prefectural highways for two-way bank maintenance, preparation of coastal forests, and marking out the edges of the tsunami inundation area with poles, from Tenjin Misaki Park we can see in one view the tsunami countermeasures for the next generation. In Tenjin Misaki Park, as a viewpoint for tsunami countermeasures, we are	

		working on the establishment of a prospective area. From now on, we will utilize the AR function for the viewpoint and build a mechanism to see the image at the time of the tsunami attack on a smartphone etc." (p62) Sports and recreation: "Tenjin Misaki Park: Shiokazeso hot spring and cycling terminal are renewed and open! New large play equipment has been installed on the wide lawn area" (p129) Disaster evacuation site: "In order to pass on the lessons and knowledge from past disasters such as the Great East Japan Earthquake to future generations and to form an area that is strong against disasters, the idea of disaster prevention is applied to the green areas / green roads and their management by considering them as evacuation destinations. By carving the idea of disaster into the idea of place, it can become fixed in culture." (p74)	
	Tourism	Tourist attraction: "Naraha Town boasts rich natural tourist resources such as the Kido River Valley, the coastal area, and Tenjin Misaki Park" (p58) Nature as tourist attraction: "We will use the rich natural environment with which we are blessed to work to restart tourism, and return to the landscape of hometown Naraha." (p62)	River Park General nature
	Aesthetic appreciation and inspiration for culture, art and design	Aesthetic quality of landscape: "Looking down from Tenjin Misaki Park on the coastline and beautiful farmland, the mountain stream of the Kido Dam and Kido River, the salmon and trout swimming in the river, this represents the original landscape of hometown Naraha." (p62) Aesthetic quality of landscape: "The agricultural land that has been built up by our ancestors is not just a place for agricultural produce, but also plays many important roles such as an idyllic country landscape" (p13) Aesthetics and sense of hometown: "Creating the landscape of hometown Naraha […] thus far, with cooperation from NPOs etc, starting with the roads in Tenjin Misaki, planting of	Park Farmland River Rice field Individual/street trees Reservoir

		cherry trees at every area in the town has continued. This will continue from now on to create a 'tunnel of cherry trees' (p62) Site for socially and culturally meaningful activities/festivals: "In October 2015, the Arukou-kai festival, which is a fixture of the town, was held in Tenjin Misaki Sports Park for the first time in 5 years" (p64)	
	Spiritual experience and sense of place	Aesthetic quality of landscape: "Looking down from Tenjin Misaki Park on the coastline and beautiful farmland, the mountain stream of the Kido Dam and Kido River, the salmon and trout swimming in the river, this represents the original landscape of hometown Naraha." (p62) Aesthetics and sense of hometown: "Creating the landscape of hometown Naraha […] thus far, with cooperation from NPOs etc, starting with the roads in Tenjin Misaki, planting of cherry trees at every area in the town has continued. This will continue from now on to create a 'tunnel of cherry trees' (p62) Source of pride and identity: "However, we cannot deny that hotspots exist, and the rich green forested mountains which are the characteristic of Naraha Town also cause worry from their contaminated status" (p106) Preservation of history/pride: "The agricultural land that has been built up by our ancestors is not just a place for agricultural produce, but also plays many important roles" (p13) Site for socially and culturally meaningful activities/festivals: "In October 2015, the Arukou-kai festival, which is a fixture of the town, was held in Tenjin Misaki Sports Park for the first time in 5 years" (p64) Disaster memorialisation: "prayer park" (p115) Symbolism of recovery: "The 'Tree of Hope,' planted to pray for revitalisation" (p136)	Park River Smaller/urban forested areas Farmland Individual/street trees Reservoir

TOMIOKA

https://www.tomioka-town.jp/material/files/group/3/keikaku_honpen.pdf, accessed 23/03/2019

Provisioning	Food	Restart of farming: "While aiming for a smooth restart of farming through protection of farmland, aim to restart local industry through efficient use of farmland" (p31) Provision of animal feed: "Through cultivation of 'sell-able' produce including animal feed and non-consumable produce, continue to expand sales channels" (p38) Services from excellent quality farmland: "In areas with excellent farmland bearing key industries, revitalisation of farmland, farm plant factories, renewable energies, continue utilisation through accumulation of various activities" (p50) Food from new farming methods: "Through uses such as plant factories and hydroponic culture, form new farming activities" (p54)	Farmland
	Raw materials	Biomass for energy: "Cherry trees are blossoming, this is a town where we can live usual life. Our home is fuelled by biomass, we have planted cherry trees, and created a town where the cherry trees of Yonomori will not be defeated. It is a town where children can play freely" (p8) Provision of raw materials (farming/forestry/fishing): "Through mutual connection of the primary, secondary and tertiary sectors which are based on rich farming, forestry and fisheries resources, undertaking activity to improve and create added value" (p80)	Individual /street trees Forests at rural-urban periphery Rivers
	Fresh water	Fresh water resources: "Through appropriate dam management and considering the location of water resources, prepare waterway management for re-establishing sequestration" (p64)	Reservoir
	Medicinal resources		
Regulating	Local climate and air quality		
	Carbon sequestration and storage		

	Moderation of extreme events	Tsunami risk reduction: "The town's thinking: to counter a 1 in 1000 year largest-class tsunami like the Great East Japan Earthquake, we are aiming to plan a town with increased general disaster prevention capability. This will be achieved through multiple techniques for 'multiple defence', such as coast and river embankments, the prefectural Hirono-Odaka line, and coastal forests." (p14) Tsunami risk reduction through planting of strong flowering trees: "In the vicinity of the coastal forest being prepared to reduce disaster risk, plant flowering trees etc which are resistant to salt damage and create a pathway, which can allow visitors to feel that the area damaged by the tsunami is recovering" (p53) Flood control: "Protect farmland, which has multiple functions such as disaster prevention from flood control capacity and sustenance of ecosystem." (p38) Flood and landslide control via management of rivers, dams and forests: "Continuation of flood control and sequestration works: Increase disaster prevention capability through rehabilitation of rivers, dam management and continuation of forestry" (p78)	Forests at rural-urban periphery Smaller/urban forested areas Individual /street trees Farmland River Reservoir
	Waste-water treatment		
	Erosion prevention and maintenance of soil fertility		
	Pollination		
	Biological control		
Habitat/ supporting	Species habitats	Sustain ecosystem: "Protect farmland, which has multiple functions such as disaster prevention from flood control capacity and sustenance of ecosystem." (p38)	Farmland
	Maintenance of genetic diversity	Plant and tree diversity: "Cherry trees are blossoming, this is a town where we can live usual life. Our home is fuelled by biomass, we have planted cherry trees, and created a town where the cherry trees of Yonomori will not be defeated. It is a town where children can play freely" (p8)	Plant matter Individual /street trees Flowers

		Plant and tree diversity: “1. Recovery of the heart through cherry trees: Grow and protect the cherry trees of Yonomori, as a symbol of the recovery of Tomioka; Plant cherry trees to connect Yonomori cherry trees and Nishihara cherry trees, as a symbol of connecting the hearts of citizens; take cherry trees, azalea, magnolia, camellia and others as a symbol of flowers and greenery which can symbolise Tomioka’s pride” (p31)	
Cultural	Recreation and mental and physical health	Return to regular life: “Cherry trees are blossoming, this is a town where we can live usual life. Our home is fuelled by biomass, we have planted cherry trees, and created a town where the cherry trees of Yonomori will not be defeated. It is a town where children can play freely” (p8) Building of social relations: “2-2: Revitalisation Prayer Park thought of together by the town and its citizens: prepare a focal point along the coastline from Kegaya to Obama which can act as a focal point for prayers for recovery from the disaster” (p30) Building of social relations: “1. Recovery of the heart through cherry trees: Grow and protect the cherry trees of Yonomori, as a symbol of the recovery of Tomioka; Plant cherry trees to connect Yonomori cherry trees and Nishihara cherry trees, as a symbol of connecting the hearts of citizens; take cherry trees, azalea, magnolia, camellia and others as a symbol of flowers and greenery which can symbolise Tomioka’s pride” (p32) Pride in recovery and tree environment: “Planting cherry trees inside the part can be the pride of citizens and their revitalisation” (p36) Playing area for children: “In the areas of Yonomori and Oragahama where radiation is still high, assuming thorough decontamination in the areas which have been designated an area of difficult return by the government, method for the efficient use of tourism resources (Yonomori cherry trees) and excellent farmland for the revitalisation of the municipalitie and region will be considered together with citizens. Moreover, we are aiming for actions such preparing Tomioka’s symbolic Yonomori cherry trees, and a park where children can again gather, as actions which can represent the revitalisation of Tomioka.” (p56)	Individual /street trees Park Plant matter Flowers

		Connection across generations: “The concepts of Tomioka Town’s Disaster Revitalisation Plan (Second Edition) are ‘revitalisation of each of the townspeople’s hearts’ and ‘revitalisation of ‘hometown Tomioka’ which connects townspeople’s hearts.’ To achieve this, we again confirm that restart of the Yonomori Area is crucial, and with all our power we aim to restart the ‘hometown’ which connects all ages from children to elderly people with overflowing smiles” (p57) Disaster evacuation site: “4. Consider and prepare how to change parks for disaster prevention” (p64)	
	Tourism	Attract tourists to recovery memorial park: “Revitalisation Prayer Park thought of together by the town and its citizens: consider preparation plan and contents; preparation work; actions to attract tourists” (p45) Cherry blossom as resource for tourism: “Revitalise Yonomori Area, the foremost tourist resource on Fukushima’s coastal corridor which has the cherry trees citizens are proud of, and Oragahama Area where many different kinds of land uses are desired starting with the excellent farmland” (p50)	Park Individual /street trees
	Aesthetic appreciation and inspiration for culture, art and design	Cherry blossom as site and focal point for culturally-meaningful festivals: “Revitalising communities through events and festivals: aim to restart Cherry Blossom Festival in future, continue cherry trees as a gathering point for by season” (p32) “Yonomori Ward in Tomioka Town is represented by cherry blossom trees, Yonomori Park, the cherry blossom festival and others. Through the cherry trees where children up to old people gather, there is a consistent ‘hometown of the heart’ […] Since the disaster, with the thought of again being able to gather under the cherry trees of Yonomori supporting their hearts, the citizens of Tomioka have been living in evacuation over a long time period.” (p57) Attractiveness of town landscape: “New focal point and formation of attractive space: Formation of attractive space through Tomioka’s symbolic cherry trees, and undertake town planning newly with citizens.” (p78)	Individual /street trees
	Spiritual experience and sense of place	Sense of resilience: “Cherry trees are blossoming, this is a town where we can live usual life. Our home is fuelled by biomass, we have planted cherry trees, and created a town where the cherry trees of	Individual /street trees Park

		Yonomori will not be defeated. It is a town where children can play freely" (p8) Disaster memorial: "2-2: Revitalisation Prayer Park thought of together by the town and its citizens: prepare a focal point along the coastline from Kegaya to Obama which can act as a focal point for prayers for recovery from the disaster" (p30) Cherry trees as symbol of recovery and pride: "From children to elderly people, regardless of generation, from the questionnaire survey we undertook it was clear that everyone thought of cherry trees as the symbol of Tomioka and felt pride in them. Across as wide an area as possible cherry trees which have been popular so far will be kept in place, and we will continue to plant new trees for the future. Moreover, we will use not only cherry trees but also azalea etc to tell the pride of Tomioka's flowers and greenery to future generations" (p32) Site for memorials of religious significance: "Introducing the wisdom of our ancestors through the Ko'an Buddhist Statue (north area of park) and the Kegaya Buddhist Statue (south area of park), which somehow escaped the tsunami damage" (p53) Cherry blossom central to placemaking: "continue townmaking established out of cherry trees" (p65)	

OKUMA

http://www.town.okuma.fukushima.jp/uploaded/attachment/1505.pdf, accessed 23/03/2019

Provisioning	Food	Restart of farming: "In the future, we plan to make effective use of idle farmland, aim for housing of hydroponic cultivation facilities, and to be a district that plays a pioneering role in agricultural rehabilitation in town." (p13) Provision of food after decontamination: "After decontamination of farmland used for plants, promote in advance water- and animal based industry" (p40) Indoor plants as lead-in to farming: "Introduce plant factories etc as an advance lead-in to farming" (p47) Provision of fish: "using the rivers that salmon move up" (p13)	Farmland Plant matter River
	Raw materials	Materials for energy: "Using part of the farmland in the difficult to return area, trial growth of energy crops will be considered in areas where soil has absorbed radioactive matter" (p40+41) Produce for non-consumption use: "Promote advance restart of agriculture by cultivating non-edible crops such as aromatic herbs and flower plants, installation of roadside flower beds etc." (p40 + 41) Forestry resources for wood products/cross-laminated timber: "Effective utilization of forest resources through the development of CLT (wood material) manufacturing factory and regeneration of forestry" (p41) Fuel for biomass: "Cultivation of non-edible plants, such as aromatic herbs, flowers, biomass fuels" (p47)	Farmland Plant matter Forests at rural-urban periphery
	Fresh water	Effective/limited use of rivers as environmental protection zone after decontamination: "Regarding the coastal area, as above it is considered difficult to implement during the planning period, but on the assumption that it will be decontaminated, after implementing tsunami countermeasures, it will be designated as a natural protection zone effectively utilizing the coast and rivers" (p13)	Rivers
	Medicinal resources	Production of aromatic herbs: "Promote advance restart of agriculture by cultivating non-edible crops	Plant matter

		such as aromatic herbs and flower plants, installation of roadside flower beds etc." (p40 + 41)	
Regulating	Local climate and air quality		
	Carbon sequestration and storage		
	Moderation of extreme events		
	Waste-water treatment		
	Erosion prevention and maintenance of soil fertility		
	Pollination		
	Biological control		
Habitat/ supporting	Species habitats	Provision of fish: "using the rivers that salmon move up" (p13)	River
	Maintenance of genetic diversity		
Cultural	Recreation and mental and physical health	General public good: "Public site: road; park / green area; adjustment pond etc" (p12) Space for building social relations: "Neighbourhood park: In addition to creating residents' interaction and a place of relaxation, it will be utilized for events and others. In the event of a disaster, it will also serve as an evacuation site" (p12) Space for disaster evacuation: "Neighbourhood park: In addition to creating residents' interaction and a place of relaxation, it will be utilized for events and others. In the event of a disaster, it will also serve as an evacuation site" (p12) Space for recreation: "Neighbourhood park: In addition to creating residents' interaction and a place of relaxation, it will be utilized for events and others. In the event of a disaster, it will also serve as an evacuation site" (p12) Well-being from nature: "Specifically, using the rivers that salmon move up we will prepare the	Park Greenspace River Forests at rural-urban periphery

		Okuma Town Revitalisation Prayer Park to recover the sea, river, woods (forest) and peace of mind" (p13) Basis for education and research: "Domestic and overseas institutions can gather and conduct education and research such as decommissioning furnaces, environmental restoration, agriculture, forestry and fisheries. Training of nuclear engineers at home and abroad will also be conducted." (p48)	
	Tourism		
	Aesthetic appreciation and inspiration for culture, art and design	Space for events: "Neighbourhood park: In addition to creating residents' interaction and a place of relaxation, it will be utilized for events and others. In the event of a disaster, it will also serve as an evacuation site" (p12) Beautification of environment: "Promote advance restart of agriculture by cultivating non-edible crops such as aromatic herbs and flower plants, installation of roadside flower beds etc." (p40-41)	Park Flowers
	Spiritual experience and sense of place	Disaster memorial/recovery support: "Specifically, using the rivers that salmon move up we will prepare the Okuma Town Revitalisation Prayer Park to recover the sea, river, woods (forest) and peace of mind" (p13) Peace and well-being from nature: "Specifically, using the rivers that salmon move up we will prepare the Okuma Town Revitalisation Prayer Park to recover the sea, river, woods (forest) and peace of mind" (p13) Use of natural products to symbolise/support recovery: "Making bear stuffed toys from Aizu cotton" (p56)	Park River Forests at rural-urban periphery Individual/street trees

FUTABA

http://www.town.fukushima-futaba.lg.jp/5466.htm, accessed 23/03/2019

Provisioning	Food	Restoration of farming/farmland: Recovery of original landscape by agricultural regeneration utilizing farmland (paddy fields) (p48) Future rice provision: "Towards the future resumption of rice farming for consumption, assume growing crops for fuel resources and rice for animal feed" (p48) Provision of animal feed: "Towards the future resumption of rice farming for consumption, assume growing crops for fuel resources and rice for animal feed" (p48)	Farmland
	Raw materials	Provision of fuel: "Towards the future resumption of rice farming for consumption, assume growing crops for fuel resources and rice for animal feed" (p48) Plant/flowering produce: "On that basis, we will gradually initiate efforts towards resuming full-scale farming in the future, such as starting with the cultivation of flowers, fuel crops, feed crops in the agricultural revival model zone of the Morotake Area" (p 79)	Farmland
	Fresh water	Importance of decontaminating forests to ensure continued supply of clean water for farming restarts: "In addition, in order to resume future farming, decontamination of the forest holding the upstream of the river and the reservoir for agriculture is also indispensable to prevent the diffusion of radioactive substances downstream and the influence on the surrounding environment. So looking to future resumption of farming, we will ask the national government for early decontamination." (p79)	River Forests at rural-urban periphery Pond
	Medicinal resources		
Regulating	Local climate and air quality		
	Carbon sequestration and storage		
	Moderation of extreme events	Disaster/tsunami risk reduction: "In developing the Reconstruction Prayer Park, by promoting preparation in cooperation between the green	Park Smaller/urban forested areas

		area to be maintained as a coastal disaster prevention forest and the surrounding facilities affected by the earthquake disaster, green spaces and other places will fulfill not only disaster prevention but also become a place for people to relax. Cooperation with related organisations will be requested to achieve this." (p55) Disaster/tsunami risk reduction: "In addition to the coastal levees, the coastal disaster prevention forest is planned to be developed with a width of approximately 200 m, aiming at completion in around 2022, thereby further reducing the tsunami risk" (p61)	Greenspace
	Waste-water treatment		
	Erosion prevention and maintenance of soil fertility		
	Pollination		
	Biological control		
Habitat/ supporting	Species habitats		
	Maintenance of genetic diversity		
Cultural	Recreation and mental and physical health	Recreation and wellbeing: "For example: Partial turning of municipal grounds into parks; Reorganization of libraries, historical folk museums, etc" (p43) Recreation and enjoyment: "In developing the Reconstruction Prayer Park, by promoting preparation in cooperation between the green area to be maintained as a coastal disaster prevention forest and the surrounding facilities affected by the earthquake disaster, green spaces and other places will fulfill not only disaster prevention but also become a place for people to relax. Cooperation with related organisations will be requested to achieve this." (p55) Enhancing living quality of built environment: "Around the residential area, consideration is	Park Greenspace Flowers Individual/street trees Plants

		given to living environment, such as scenery of flowers and trees" (p48) Liveability of environment: "Flower Road: By cultivating flower plants, by improving the surrounding landscape, it has a great meaning from a farming point of view as well as from a town planning point of view." (p79) Enhancing living quality of built environment: "It is desired to create an environment where the flowers of the season can be enjoyed" (p91) Recreation/walking opportunities: "Preserve and revitalize cherry blossoms such as at Maeda River and promote the improvement of the environment of the townscape (example: pathways etc.)" (p43)	
	Tourism	Park as service/information site for visitors: "A base for providing services to visitors to reconstruction prayer park (Industry promotion and regional revitalization through sale of local products and provision of meals using produce from Fukushima Prefecture)" (p50)	Park
	Aesthetic appreciation and inspiration for culture, art and design	Aesthetic quality: "Flower Road: By cultivating flower plants, by improving the surrounding landscape, it has a great meaning from a farming point of view as well as from a town planning point of view." (p79) Aesthetic quality of cherry blossoms: "Town centre revitalisation zone: Maeda River cherry blossoms (Futaba Town)" (p40)	Flowers Plants
	Spiritual experience and sense of place	Archive and disaster memorialisation: "Archive facility focal point and Revitalisation Prayer Park" (p5) Symbol of recovery: "The symbol of recovery and Revitalisation Prayer Park" (p46) Symbolisation of recovery: "Town centre revitalisation zone: Maeda River cherry blossoms (Futaba Town)" (p40) Symbolisation of recovery: "Continue to arrange the town's landscape and environment through preservation and revitalisation of cherry trees in locations such as Maeda River (for example: pathways etc)" (p43)	Park Individual/street trees River

		Identity and sense of place: “Continue to arrange the town’s landscape and environment through preservation and revitalisation of cherry trees in locations such as Maeda River (for example: pathways etc)” (p43)	

NAMIE

http://www.town.namie.fukushima.jp/uploaded/attachment/6869.pdf, accessed 23/03/2019

Provisioning	Food	Restart of farming: "In addition, trial cultivation for agricultural land conservation and resumption of agriculture, consideration for resumption of fisheries was promoted, and efforts toward the revitalization of the hometown have also begun starting from the townspeople themselves" (p12) Restart of farming (including flower cultivation): "New special products such as flowers are created, and are becoming a highlight of the town." (p15) Fish from rivers: "Restart of fisheries towards revitalisation of the sea and rivers" (p19) Farming as industry: "We will revitalize the farmland throughout the town and create an environment where one can make a livelihood from various kinds of agriculture." (p30) Provision of food/economic benefit: "Regenerate local products and expand sales channels, develop special products, and convert agricultural, forestry and fishery products into the 'sixth industry' (unification of production, processing, sales)" (p46)	Farmland River Plant matter Forests at rural-urban periphery
	Raw materials	Forestry and forest products: "In agriculture, farming restarts, new farming methods, resumption of fisheries by revitalisation of the sea and river, conversion to a new type of forestry, etc. can play a role towards regeneration of primary industries throughout the town." (p19) Forest resources: "Forest resources" (p26) Biomass energy: "Development of town planning using forest resources: Satoyama revitalization model project, and promotion of utilization of woody biomass" (p27)	River Forests at rural-urban periphery Individual/street trees
	Fresh water	Clean and safe water for farming activities: "We aim to regenerate agricultural land, promote measures to restore soil functions and secure safe water for safe use." (p33)	Farmland River

		Importance of fresh river water for sense of security: “Because Namie Town's difficult-to-return area includes the upper stream area of the river, in order to live a safe life throughout the town, it is necessary to rigorously reduce the dose in the surrounding areas such as rivers and river beds.” (p42)	
	Medicinal resources		
Regulating	Local climate and air quality		
	Carbon sequestration and storage		
	Moderation of extreme events	Disaster prevention: “As a measure against tsunamis, tide breakwaters and disaster prevention forests are in place.” (p15)	Smaller/urban forested areas
	Waste-water treatment		
	Erosion prevention and maintenance of soil fertility	Restore soil functions through environmental management: “We aim to regenerate agricultural land, promote measures to restore soil functions and secure safe water for safe use.” (p33)	Farmland
	Pollination		
	Biological control	Weeding to reduce damage/effects of wild boars: “Weeding of wild vegetation will be undertaken to sustain our beautiful hometown. Also, we will consider effective countermeasures against harmful birds and beasts (wild boars etc), and take measures in view of the lived environment and farmland protection” (p37)	Wild vegetation
Habitat/ supporting	Species habitats	Fish from rivers: “Restart of fisheries towards revitalisation of the sea and rivers” (p19)	
	Maintenance of genetic diversity		
Cultural	Recreation and mental and physical health	Site for communication and exchange: “We will utilize the newly developed Reconstruction Prayer Park and exchange and information dissemination sites, to transmit messages such as the experience of the disaster that we can tell because we are Namie Town” (p46) Sense of safety and naturalness: “We will return to the radiation dose before the earthquake throughout the living area in the	Park Forests at rural-urban periphery Smaller/urban forested areas River

		town, regaining the environment that everyone can live with peace of mind. Also, for the planned implementation of the Satoyama reclamation project and measures to reduce radiation, when decontamination of all the vast forests has been completed, it will enable an environment that can again touch rich nature, including rivers and oceans, as it did before." (p18) Sense of pride and resilience: "We do not give up, we revitalize agriculture, forestry and fisheries (these are our efforts so far) - Many people are working toward resumption / revival in the town ~" (p44) Disaster education and memorialisation: "We will continue to consider how to use existing facilities to tell the earthquake disaster story and undertake disaster prevention education. In doing so, we aim for effective dissemination through collaboration with the Reconstruction Prayer Park." (p48) Area for park/recreation: "In 2015 we held a district conference (4 times) and heard opinions. The reconstruction prayer park was set up in the tsunami disaster area of Namie Town - Futaba Town (50 ha)" (S159)	
	Tourism	Excursions to memorial park and port: "Moreover, through excursions to the area around the Revitalisation Memorial Park and Ukedo Fishing Port, various activities can happen" (p16) Natural environment – e.g. Takase River Valley – as tourist destination: "Through moving through means such as electric vehicles, it will be possible for tourism to scenic spots such as the Takase River Valley" (p19)	Park River
	Aesthetic appreciation and inspiration for culture, art and design	Return of natural beauty through management of weeds: "Weeding of wild vegetation will be undertaken to sustain our beautiful hometown" (p37) Flower cultivation: "Cultivation of paddy rice, vegetables and flowers has started, some of the crops have been shipped inside and outside the prefecture after passing safety checks" (p13)	Wild vegetation Flowers

		Flower road in coastal area: “Maintaining flower roads in the coastal area, creating a round route to connect the Revitalisation Prayer Park, harbor, and town centre” (p14)	
	Spiritual experience and sense of place	Disaster/recovery memorial: “Revitalisation Prayer Park” (p13) Disaster education and memorialisation: “We will continue to consider how to use existing facilities to tell the earthquake disaster story and undertake disaster prevention education. In doing so, we aim for effective dissemination through collaboration with the Reconstruction Prayer Park.” (p48) Sense of recovery of hometown: “In addition, trial cultivation for agricultural land conservation and resumption of agriculture, consideration for resumption of fisheries was promoted, and efforts toward the revitalization of the hometown have also begun starting from the townspeople themselves” (p12) Source of pride pre-disaster: “The rich surrounding natural environment of sea, mountains and rivers, which Namie Town was able to boast of, was severely hurt by radioactive contamination. While the whole town was evacuated or under restriction orders, there was no way to stop the devastation of the town’s land” (piii)	Park River

KAWAUCHI

http://www.kawauchimura.jp/page/page000145.html, accessed 23/03/2019

Provisioning	Food	Provision of farm produce: "Promotion of cultivation of agricultural crops after decontamination of agricultural land, ensuring safety on harvested products, cultivation of sales channels, countermeasures for harmful rumours" (p8) Plant cultivation as pathway to farming restart: "Produce from plant factories and farmers who resumed farming, etc. are will be promoted by mobile sales vehicles, and new business and farming resumption will be promoted." (p6)	Farmland
	Raw materials	Building material for houses: "However, the mountains are Kawauchi's assets, and just now we are learning what kind of environment is in the mountains, undertaking experimental forestry and demonstration projects to facilitate the construction of simple houses with the calculated timber resources" (p6) Fuel for biomass energy: "Utilization of residual heat of woody biomass power generation in house cultivation" (p4)	Individual/street trees
	Fresh water	Need to decontaminate rivers: "Implement decontamination by appropriately reviewing decontamination plans (including decontamination of forests, rivers, etc)" (p3)	Forests at rural-urban periphery River
	Medicinal resources		
Regulating	Local climate and air quality		
	Carbon sequestration and storage		
	Moderation of extreme events	Need for management of river banks/vegetation to reduce flood risk: "Significant wild vegetation is flourishing due to the inability to manage rivers. This will interfere with the rainfall when water rise rises, risking human life risk, so the vegetation needs to be managed and cut properly." (p6)	River Wild vegetation
	Waste-water treatment		
	Erosion prevention and		

	maintenance of soil fertility		
	Pollination		
	Biological control		
Habitat/ supporting	Species habitats		
	Maintenance of genetic diversity		
Cultural	Recreation and mental and physical health	Management of forests for creating safe and secure living environment: "Forest city concept: We aim to create safe and secure residential areas protected from radiation, develop forests and improve the environment" (p6)	Forests at rural-urban periphery
	Tourism		
	Aesthetic appreciation and inspiration for culture, art and design		
	Spiritual experience and sense of place	Forests key to sense of place and quality of life (but lost because of feeling of stress/unease from accident): "As Kawauchi Village is nine-tenths forest, we could have a lifestyle where we enjoyed the rich elegance of the mountains. Because of the nuclear accident this lifestyle changed completely, and with a feeling of anxiety from the contaminated mountains it was not possible to live here. However, the mountains are Kawauchi's assets, and just now we are learning what kind of environment is in the mountains" (p6)	Forests at rural-urban periphery Individual/street trees

KATSURAO

https://www.katsurao.org/uploaded/attachment/42.pdf, accessed 23/03/2019

Provisioning	Food	Restart of farming (after decontamination): "To improve the effective use of agricultural land after decontamination, large-scale field improvement will take place" (p15) Restart of farming (after decontamination): "Rather than relying on the survey and judgment of the national government, the village will conduct its own unique soil survey specific to the village, with the aim of restoring the farmland that provides reassurance and produces agricultural crops. Based on comparison with the results of the national government survey, the village will request decontamination methods from the national government" (p24) Farming and food provision: "Advance the construction of plant factories and similar on existing agricultural land, and support the production of various agricultural products such as flowers and mushrooms" (p39) Mushroom farming in forests/trees: "undertake work to revitalise original forests for mushroom growing" (p39)	Farmland Plant matter Individual/street trees Forests at rural-urban periphery
	Raw materials	Forestry and logging: "Whilst intensively carrying out the production of special forest products (mushrooms), we carry out planned tree planting and logging across a wide area for original forest industries" (p15) Use of local wood for reconstruction building materials: "Monitoring to support the safety and reliability of forest products such as timber materials, and utilize thinned wood as a reconstruction building material" (p28) Biomass energy: "We actively work to attract new enterprises, promote the utilization of forest timber for biomass power generation etc, and seek support from the national government for the construction of facilities" (p28)	Forests at rural-urban periphery Individual/street trees River

		Biomass energy: “Taking advantage of the forest that occupies 80% of the village, we will promote the attraction of research facilities and companies related to biomass, and introduce and utilize renewable energy such as solar power, wind power, and small scale hydroelectric power generation” (p34) Water resources for electricity: “Utilizing the Katsurao River from Natsuyu to Onanachi, we will promote the small hydroelectric power generation project. We will onstruct 3-4 small power plants, prepare for continuous operation of the project, and develop a water store park in the vicinity. In addition to providing the electricity obtained from here to each family in village, we will proceed to supply to enterprises and sell electricity to power companies” (p15)	
	Fresh water	Forests provide water for farming – risk from radiation contamination: “Request to the country and Tokyo Electric Power to properly implement treatment for decontamination of forests as a source of agricultural water; and provide compensation for property such as agricultural machinery and warehouses, and treatment of agricultural industrial waste” (p24) Forests preserve water resources: “Forests are the treasure chest of water resources and have disaster prevention potential, so through decontamination combined with asking the country for support with appropriate preparation, we will support the recovery of forest industries.” (p39)	Forests at rural-urban periphery River
	Medicinal resources		
Regulating	Local climate and air quality		
	Carbon sequestration and storage		
	Moderation of extreme events	Forests have disaster prevention function: “Forests are the treasure chest of water resources and have disaster prevention potential, so through decontamination combined with asking the country for support with appropriate preparation, we will support the recovery of forest industries.” (p39)	Forests at rural-urban periphery

	Waste-water treatment		
	Erosion prevention and maintenance of soil fertility	Need to return soil and farmland to original quality: “Regarding the decontamination of agricultural land, we ask the country not only for decontamination, but also to restore the function of the farmland, as well as to provide extensive compensation until it is restored as farmland” (p24)	Farmland
	Pollination		
	Biological control		
Habitat/ supporting	Species habitats	Provision of food for animal husbandry: “In order to facilitate the promotion of livestock across the village, cultivate crude feed by making use of idle farmland, and prepare for the supply of coarse feed.” (p15)	Farmland
	Maintenance of genetic diversity		
Cultural	Recreation and mental and physical health	Assembly site for evacuation: “Start of evacuation at Azuma General Exercise Park” (p45) Public good in daily life: “Public facilities such as roads, rivers, agricultural facilities, schools and social welfare facilities are facilities that are necessary for citizens’ daily lives, for protection of social welfare, for the sustenance of farming and forestry etc. Therefore, we ask the country for support concerning maintenance of facilities damaged by the earthquake and other disasters” (p27)	Park River Farmland
	Tourism	Forest for tourism: “Forest part development zone: continuing development of the Mori Mori Land Park, which has been a tourism resource up until now, and consider the foothills on the east side of Mt Ryuko” (p15) Park as tourist resource: “At the same time as promptly restoring afflicted disaster-affected cultural heritage, we strive to utilise historical site parks and tourism resources to preserve cultural traditions” (p37)	Forests at rural-urban periphery Park
	Aesthetic appreciation and inspiration for culture,	Site for festivals and culturally meaningful activities: “Culture such as festivals, performing arts and ceremonies, cultural resources such as the Katsurao Daijin-ya Ruins Park, and the nature in sites such as the prefectural park, are all a source of pride for villagers and symbols of	Park

	art and design	Katsurao. Therefore, we will support protection of local traditional culture and nature, and landscape resources such as historical buildings, and will support promotion activities in this area" (p36)	
	Spiritual experience and sense of place	Preservation of history and traditions: "At the same time as promptly restoring afflicted disaster-affected cultural heritage, we strive to utilise historical site parks and tourism resources to preserve cultural traditions" (p37)	Park

REFERENCES

Blomberg J, Giacomi J, Mosher A and Swenton-Well P (1993) 'Ethnographic field methods and their relation to design' in Schuler D and Namioka A (eds) *Participatory Design: Principles and Practices* Laurence Erlbaum Associates: New Jersey pp 123-156.

Futaba Town (2016) *Futaba Town Recovery Urban Plan (Second Edition)* (in Japanese) Futaba Town: Futaba.

Hirono Town (2014) *Hirono Town Recovery Plan (Second Edition)* (in Japanese) Hirono Town: Hirono.

Katsurao Village (2012) *Katsurao Village Recovery Plan (First Edition)* (in Japanese) Katsurao Village: Katsurao.

Kawauchi Village (2013) *Kawauchi Village Recovery Plan* (in Japanese) Kawauchi Village: Kawauchi.

Namie Town (2017) *Namie Town Recovery Plan (Second Edition)* (in Japanese) Namie Town: Namie.

Naraha Town (2016) *Naraha Town Recovery Plan (Second Edition)* (in Japanese) Naraha Town: Naraha.

Okuma Town (2015) *Okuma Town Second Recovery Plan* (in Japanese) Okuma Town: Okuma.

Tomioka Town (2015) *Tomioka Town Disaster Recovery Plan (Second Edition)* (in Japanese) Tomioka Town: Tomioka.