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Cumulative effects assessment: Does scale matter?

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Abstract

Cumulative effects assessment (CEA) is (or should be) an integral part of environmental assessment at both the project and the more strategic level. CEA helps to link the different scales of environmental assessment in that it focuses on how a given receptor is affected by the totality of plans, projects and activities, rather than on the effects of a particular plan or project.

This article reviews how CEAs consider, and could consider, scale issues: spatial extent, level of detail, and temporal issues. It is based on an analysis of Canadian project-level CEAs and UK strategic-level CEAs. Based on a review of literature and, especially, case studies with which the authors are familiar, it concludes that scale issues are poorly considered at both levels, with particular problems being unclear or non-existing cumulative effects scoping methodologies; poor consideration of past or likely future human activities beyond the plan or project in question; attempts to apportion 'blame' for cumulative effects; and, at the plan level, limited management of cumulative effects caused particularly by the absence of consent regimes. Scale issues are important in most of these problems.

However both strategic-level and project-level CEA have much potential for managing cumulative effects through better siting and phasing of development, demand reduction and other behavioural changes, and particularly through setting development consent rules for projects. The lack of strategic resource-based thresholds constrains the robust management of strategic-level cumulative effects.

Keywords: Cumulative; Cumulative impact assessment; Cumulative effect assessment; Strategic environmental assessment; Scale

1. Introduction

If EIA assesses the effects of a project to identify and mitigate its key effects, and SEA is the same thing for strategic actions, then cumulative effects assessment (CEA) cuts in the opposite

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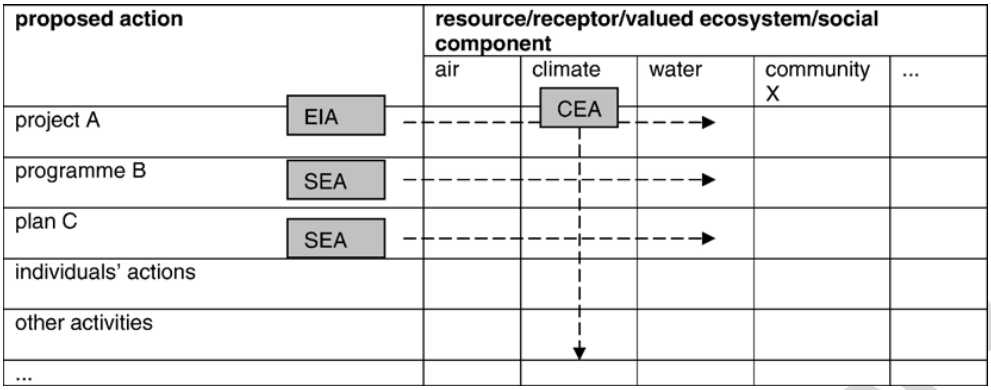

Fig. 1. EIA, SEA, CEA.

direction. Instead of focusing on the effects of a given action – a project, plan, or individuals' behaviour – it focuses on the receiving environment and considers all of the effects on a given receptor. Fig. 1 illustrates this. Cumulative effects could be:

- all of the transport, industrial, domestic heating etc. activities that are leading to global warming (receptor = the world's climate)
- the progressive increase in night time lighting – of roads, stadia, pretty church spires, people's back yards to deter intruders – that is contributing to a generation of children who can't see stars as clearly from outside their houses as their parents could (receptor = people who can see black skies)
- all of the effects of multiple project or plan components on one community: noise, air pollution, deprivation etc. (receptor = the residents of the community)[2]

The ultimate test of CEA is whether it helps to protect and improve the quality of the receiving environment.

CEA has been required as part of many countries' project EIA (and latterly also SEA) systems for years, and is supported by a range of guidance internationally (e.g., CEAA, 1998, 1999; Court et al. 1994; European Commission, 1999, 2000; ODPM, 2005a, 2005b; Scottish Executive, 2006; USCEQ, 1997). For example the European Directive on SEA requires the evaluation of cumulative and synergistic impacts (European Commission, 2001). The main steps of CEA are:

1. identify the affected receptors — also described as valued ecosystem components, receivers or resources (scoping);
2. determine what past, present and future human activities have affected or will affect these receptors, and what has led to these activities (context);
3. predict the effects on the receptors of the project/plan in combination with the effects of other human activities, and determine the significance of the effects; and
4. suggest how to manage the cumulative effects. (Ross, 1998)

[2] Other examples of cumulative effects are habitat fragmentation from housing, roads, and other development; accumulation of toxins in Arctic mammals; loss of tranquillity; and dioxins in rivers and fish coming from several different industrial sources. Cumulative effects can also be social, for instance decline of indigenous languages or traditional skills, changes in social structures, and increased reliance on the tourism economy.

One of the main benefits of SEA was meant to be that it should allow for a better consideration of cumulative effects than project EIA (e.g. Fischer, 2002; Therivel, 2004). This is important because it is only the total (i.e. cumulative) effects that matter to the environmental resources or people affected by them. But does this actually happen in practice? Can we learn anything from SEA-linked CEA practice that could support better project-level CEA, and vice-versa (crossover in scales)? Are different CEA approaches, tools and levels of detail needed for CEAs covering larger areas (typically policies and plans) than those for smaller areas (typically projects)?[3]

This article aims to describe and reflect on past CEA practice, in order to inform future practice. It moves backwards through the CEA process, from effect management to scoping, because it is impossible to get to good management without good prediction; good prediction without a good understanding of the background context; or a good context description without good scoping. For each stage, it starts with some examples of how the stage has been carried out in practice, using examples from English plan or programme CEAs and Canadian project CEAs[4]; discusses issues emerging from these examples, focusing on scale-related issues; and suggests some practical conclusions related to that CEA stage. The article concludes with a discussion of how scale issues affect CEA.

The article assumes that the reader is broadly familiar with EIA and SEA; and with their legal requirements to analyse cumulative effects. The European Commission (1999), Canadian Environmental Assessment Agency (1998), Cooper (2004) and Therivel (2004) provide such background information. While the article relies on Canadian and English examples, it purposely does not cite the specific legislative or regulatory rules in those countries because it aims to focus on scale issues and cumulative effects, and not to dwell on regulatory matters.

2. Management of cumulative effects

We start at the end of the CEA process – management of effects – because this is where the ultimate effectiveness of CEA can best be tested: does the CEA component of EIA or SEA help to protect and improve the quality of the receiving environment, over and above the rest of the EIA or SEA? We refer to this as the management stage because it involves allocating resources to achieve (in this case environmental) goals. Management of cumulative effects includes:

- avoidance and mitigation: dealing with an effect to reduce its magnitude or avoid it altogether;
- compensation (e.g. the creation of a new wetland to compensate for a lost wetland and other no-net-loss approaches);
- follow-up or monitoring studies that can trigger management action, as in adaptive environmental management (monitoring, evaluation and management); and
- at the more strategic level, rules for siting, phasing and managing projects.

[3] This article differentiates between the different components of scale as identified in João (2005): "Scale has two key meanings in SEA: firstly, scale as the extent of the assessment (e.g. size of area studied); and secondly, scale in terms of the amount of detail or granularity used (e.g. map scales, rate of sampling). Extent determines the size of the 'window' to view the world, while the amount of detail is related to the level of resolution and determines the smallest entities that can be seen in the study. The notion of scale can be applied both to temporal and spatial aspects, and both are important to SEA".

[4] This article does not suggest that there are any hierarchical links between Canadian project CEAs and UK strategic CEAs; in practice, it is difficult to find *any* good examples of CEA, much less *tiered* examples.

2.1. Past practice

At the project level in Canada, management measures put in place in response to CEA include:

- The CEA for the Cheviot opencast coal mine in Alberta identified existing significant adverse (cumulative) effects on grizzly bears (an indication of wilderness in the region) caused by existing mines, oil and gas operations, forest harvesting and recreational users. The solution to the problem of how to fit a new mine with modest effects on grizzlies into a region that already had more than an acceptable effect on grizzlies was the creation of a "carnivore compensation program", to which the dominant forestry company, some oil and gas interests, some mining companies and the Alberta Government (responsible for recreational use) contributed. This programme, a condition for approving the mine in 1996, aimed to reduce the magnitude of existing effects such that the post-Cheviot Mine effects would be less than those before the mine. The programme's success is not yet known, since the Cheviot Mine was, until recently, put on hold due to market forces (Creasey and Ross, 2005).
- As a condition for receiving project authorization under the Canadian Fisheries Act, proponents must demonstrate how they will achieve no net loss of fish habitat and, as a precautionary matter, must compensate two for one. While such approaches are very important in principle, studies by the Department of Fisheries and Oceans have demonstrated that this measure has been somewhat ineffective in practice, with actual alterations to habitats often being much larger and compensation areas smaller than those agreed (Quigley and Harper, 2004).
- The CEA for the proposed Keenleyside Dam identified that the cumulative effects caused by several existing dams on the Columbia River were approaching the threshold for becoming unacceptable. In response, the proponent hydroelectric company reduced the effect of the Keenleyside Dam. This was because the company had plans for future dams on the same river, and the reduced effects made ecological room for the company's future dams (Stalker, pers. comm., 1998).
- For the Alberta-Pacific Pulp Mill, there was a concern about the cumulative effects of adding biochemical oxygen demand into the Athabasca River, primarily from pulp mills. The concern was that, under winter ice (no re-aeration), dissolved oxygen downstream would drop too low to support fish. The solution was for the operators of several pulp mills to commit to monitor the dissolved oxygen and, should it drop below the agreed limit of 5 mg/L, corrective action would immediately be taken by the several mills together.

At the strategic level in England, CEA-related mitigation has primarily emerged in response to the European Commission's (1992) Habitats Directive rather than directly linked to SEA[5]. The Habitats Directive identifies a pan-European network of sites – Natura 2000 – and requires "appropriate assessment" for any plan or project, alone or in combination with other plans or projects, that is likely to have a significant effect on such a site. The EC (2000) guidance particularly refers to the need to assess cumulative effects over time, and underlying trends in cumulative effects. If it cannot be ascertained that the plan or project will not adversely affect the

[5] This may be in part because the SEA Directive has been in force for less than 2 years, and many authorities are still struggling with the basics of the Directive, much less its CEA requirements.

integrity of the site, then it should not be permitted unless there are no alternative solutions and it needs to be carried out for imperative reasons of overriding public interest. In such cases the Member State must take all compensatory measures necessary to ensure the overall coherence of the Natura 2000 network. Examples of resulting mitigation measures are 3-for-1 compensation, "subject to further review", for intertidal habitat lost to flood management works in the Humber Estuary (Environment Agency, 2005); and compensatory habitat provision for any housing developments built near the Surrey Heaths (Box 1).

Where SEAs have not been supported by the rigorous compensation requirements of the Habitats Directive, their CEAs have still had some effect, for instance:

- limited changes in a regional spatial strategy to help reduce cumulative climate change effects. Box 2 summarises the options discussed and why the final decision was taken;
- in a plan which would further reduce the already limited quantity of open space per person in a London borough, the addition of an open space target and some implementing mechanisms: "The Council will seek to protect, increase and improve the provision of all types of open spaces in the Borough, to a standard of 1.2 hectares per 1000 population, and improve

Box 1
Example of buffer zones and compensation as mitigation for cumulative effects: Surrey Heaths Special Protection Area (SPA)

The Surrey Heaths Special Protection Area has been designated because of its heathland birds, and is subject to appropriate assessment under the Habitats Directive. Cumulative recreational disturbance – particularly the effect on ground nesting birds of people walking their dogs – is a key effect on the Surrey Heaths. In 2005, Natural England (the UK government body responsible for biodiversity) proposed compensation rules for any housing near the Surrey Heaths. These were based on three buffer zones, at 400 m, 1 km and 5 km. No new housing development would be allowed within 400 m of the heaths, and within the other buffer zones any new housing would need to be accompanied by the provision of new or improved open space.

Recently a planning inspector has amended this approach so that a new housing development of more than 10 dwellings located between 400 m and 5 km of the heaths needs to provide 8 ha of new or improved open space at a scale of 8 ha per 1000 population; and residential developments of over 50 houses between 5 and 7 km of the heaths will be assessed on an individual basis.

The new open space would aim to provide alternative recreational facilities, to reduce recreational effects on the Surrey Heaths of both current users and the residents of any new housing. Provision of the alternative open space must take into account not only the distance of housing from the heaths, but also the quantity of new open space provided, the size of the new sites (minimum sizes would be required), their distance from housing developments, and their quality. New sites must be easily accessible, local, provide for letting dogs off leads, and provide a qualitatively similar experience to the Surrey Heaths site — i.e. they should be semi-natural and informal (Burley, 2007).

Box 2
Climate change mitigation in the Yorkshire and Humber Regional Spatial Strategy

Under current trends, neither the national UK nor the Yorkshire and Humber region's regional greenhouse gas emissions reduction targets are likely to be met. As part of the development of the Regional Spatial Strategy for the Yorkshire and Humber region, the Yorkshire and Humber Assembly commissioned consultants to identify what the strategy could do in terms of climate change. The study (Land Use Consultants et al., 2005) concluded that many climate change effects in the region are due to forces beyond the control of the strategy, for instance individuals' lifestyles and the choice of fuel by power station operators. The study also noted that the strategy can legally include any rational climate change policy that relates to the region and use of land; is not obliged to pursue all climate change objectives to the maximum extent; and needs to have good reasons to depart from national policy and standards.
The (separate) SEA for the strategy (Levett-Therivel and EDAW, 2005) considered several alternative approaches that the strategy could take to minimising/avoiding climate change (as well as measures for adapting to climate change):

1. Don't go beyond national standards, e.g. building construction standards
2. *Require* mitigation beyond national standards
3. *Encourage* mitigation beyond national standards
4. Different approaches for different sub-areas, e.g. less stringent requirements for parts of the region in need of regeneration
5. Complementary policies, e.g. local supply networks, making urban areas more attractive places.

The Yorkshire and Humber Assembly decided to follow a combination of approaches 1 and 5, explaining that:

"It is not realistic or reasonable to include a requirement to exceed national building standards due to legal problems (i.e. [the regional and local authorities] could be held to be ultra vires in setting requirements that are addressed through other legislation other than Planning Act powers), economic problems (i.e. developers would find it less profitable to build in the region, thereby reducing the number of homes built in region) and social problems (i.e. a lower number of house completions could result in fewer affordable homes being built)… Government provides an Energy White Paper which aims for a 60% cut in CO_2 by 2050, [and has backed this up with related Building Regulations] … Local Planning Authorities are unwilling to support excessive standards due to the reasons outlined above. The RSS is very limited as to what it can do in climate change terms (because RSS must be spatially orientated); other strategies/action plans have to play their part too."

accessibility to, between and within open spaces…. Communal amenity spaces will be required for all sites proposing 10 or more residential units… [Where open space cannot be provided in the immediate area of the site], the Council will seek [developer] contribution towards the improvements of open space" (LB Tower Hamlets, 2005).

These examples suggest that CEAs can and sometimes do result in the effective management of cumulative effects. This is not a universal belief. Duinker and Greig (2006, p 153) observe: "Cumulative effects assessment (CEA) in Canada… has not lived up to its glowing promise of helping to achieve sustainability of diverse valued ecosystem components."

The examples raise several issues. First, solutions to cumulative problems are often felt to be someone else's remit ("Government") or unacceptable to others ("local authorities are unwilling"). This very prevalent mindset is a major hindrance to effective CEA management. A linked issue is remit. A proponent can be forced to manage their own effects, but cannot be made responsible for managing the effects of others. Most cumulative effects require cumulative solutions: the concerted action of multiple pulp mills, local authorities or countries.

Some cumulative effects are of the type best described as the death by 1000 cuts; each individual effect is insignificant but the accumulation of the many insignificant effects causes a significant adverse effect. Two ways of dealing with these many small effects are: (1) to prevent proposed human activities for which the assessments have been done, even though their effects are (individually) insignificant, or, (2) for those proposed projects, to make the cuts (effects) smaller, i.e. to mitigate the seemingly insignificant effects. This approach is much easier to apply to future human activities than to existing ones that already have (explicit or implicit) authorization. Assessment of the cumulative effects must thus be done at a scale that will allow identification of such opportunities.

Resource-based targets or limits are keys to stimulating careful thought about, and robust management of, cumulative effects. In most of the examples discussed above, the agreed management measures would probably have been much weaker if targets or standards had not been in place. The quote at the end of Box 2 certainly suggests that voluntary, unilateral targets are difficult to set because any target could be perceived to be arbitrary and thus subject to challenge by developers; and strong management measures could be perceived as restricting development, particularly in economically vulnerable areas. Even where voluntary targets are set, implementation could well be a problem. For instance, in the Tower Hamlets example above (LB Tower Hamlets, 2005), there is no clear link between the requirement for developers to provide communal amenity spaces and the achievement of Tower Hamlet's new open space standard.

2.2. Does scale matter?

Policies, plans and programmes are typically prepared by government bodies, which are responsible to the electorate as a whole. Government bodies are thus less subject to the pressures and interests of the market place than individual project developers are. They are by nature more forward-looking and focus on a broader scale, and thus consider a wider range of activities and effects over a longer timeframe. Strategic actions can provide a proactive and universally applicable set of rules that all developers ought to follow. As such, one would expect strategic-level CEA to lead to better management measures. On the other hand, government bodies want to remain elected, are perpetually short of money, and want to promote development to ensure that their localities are economically buoyant. In that sense, they feel the same pressures and constraints as project proponents, and this will be reflected in the CEA process.

Because of the broader scale at which such CEAs are carried out, a wider range of management measures will be possible at the strategic level. Such measures include not only project-level measures (e.g. require a given type of management for each project), but also locational measures (allow projects here but not there); cross-project measures (e.g. individual developers contribute

to a fund to deliver a management goal); demand reduction measures and other measures to promote behavioural change by individuals (e.g. congestion charging); and other strategic measures (e.g. building densities). The larger physical extent of most plans or programmes allows scale-based measures to be put in place that are infeasible for most projects (e.g. new parks that serve multiple housing projects). The greater temporal extent of plans and programmes allows for time-related management measures (e.g. *X* cannot be built until *Y* is in place).

On the other hand, it is easier to require management measures for projects than for plans and programmes. Most projects that are large enough to cause significant cumulative effects will be subject to a consent regime, so that project authorization can be made conditional on certain management measures. At the plan or programme level, unless standards or thresholds have been externally imposed, management of cumulative effects will be voluntary, and thus less likely to occur. The point is that scale matters in the ability to manage cumulative effects.

In the end, the effectiveness of any management measures is primarily determined by individual decision makers and their responsiveness to the CEA findings. Cumulative effects are only managed if decision makers decide that they should be managed, and if they have the clout to impose management measures. A key role for strategic-level CEA could be to set management frameworks for project CEAs, to help to provide that clout.

2.3. Effective management of cumulative effects

Factors that support effective management of cumulative effects thus include:

- Strong legal requirements for cumulative effect management (e.g. not being granted necessary authorizations until mitigation has been put in place), and informed and proactive decision makers;
- Measures that are within the remit of the project developer or plan-making authority;
- Support for inter-developer and inter-authority development of CEA management measures;
- A consistent approach to all development that provides certainty, a level playing field, and an equitable approach so that nobody can claim to be particularly disadvantaged. For instance, thresholds or limits that trigger mitigation measures help to simplify negotiations between multiple organisations. It is much harder to get case-by-case agreements about management measures for multiple individual projects than to have one rule that applies to all projects;
- Measures that are practical and not subtly self-defeating (e.g. that do not encourage rebellious counter-behaviour such as illegal dumping of rubbish, or drivers using side streets to avoid congestion charges on main roads). The Surrey Heath measures, which specify the type of open space to be provided (large, wild, near housing), are likely to be effective. Simpler measures that, say, would only require the provision of open space could, for instance, lead to lollipop trees on closely mown grass: yes, this is open space, but it is not likely to lure dog walkers away from the sensitive heathland;
- A proactive approach that doesn't constrain people's behaviour after they have already made decisions and have entrenched views. For instance, it is easier to impose zoning-like conditions letting potential developers know that certain types of future development (those that contribute to significant adverse cumulative effects) are not welcome than to impose management measures retroactively;
- Follow-up or monitoring studies linked to management (e.g. requirements to keep fixing things until the established goal has been achieved), to ensure that the measures work as planned (see for example Morrison-Saunders et al, 2004). The follow-up programmes should

be developed in collaboration with the appropriate regulator(s) and possibly community members. Independent, broad based monitoring agencies often lead to excellent monitoring and management programmes (Ross, 2004).

3. Prediction of cumulative effects

Cumulative effect prediction involves identifying:

1. the total effects on a resource arising from different components of the plan or project (intra-plan or intra-project effects); and
2. the total effects of the plan or project in combination with those of other human activities (inter-plan or inter-project effects).

3.1. Past practice

To date, despite the legal requirement in the UK to assess cumulative effects, only a few SEAs have done so in any real detail, say in more than a paragraph, and only a very few have considered inter-plan effects. Examples of SEA CEA predictions include:

- The SEA for the Yorkshire and Humber Regional Spatial Strategy first assessed different components ("policies") of the strategy against a range of SEA objectives. The results were summarised in a matrix, part of which is shown at Table 1a. The cumulative effects of all these policies (the intra-plan effects) were then identified in the last row of Table 1a, and described in more detail, as shown at Table 1b. Finally, the intra-plan cumulative effects were considered alongside the cumulative effects of other activities, as shown at Table 2. This is a 'true' CEA approach in that it focuses on the resource rather than the plan, and considers the full range of cumulative effects (not just, for instance, effects on designated habitats). In practice, this very rapid, qualitative appraisal was well supported by a range of stakeholder groups, but led to very few changes to the strategy itself.
- The SEA CEA of the Buckinghamshire Local Transport Plan included tables like those at Table 1a, but that listed not only the plan components, but also the effects of other known plans and programmes.
- The Derbyshire Local Transport Plan proposes a range of new road links. The plan's SEA CEA assigned scores to different types of effects on each road link, and then added them up for each road link to show which links would have the greatest 'cumulative environmental score' per kilometre of road.
- To support the Surrey Heath mitigation measures (Box 1), more detailed and justified predictions of the effects of recreational activities on heathland birds were carried out.

None of these explicitly addressed space-time lags, critical thresholds, or anything beyond simple interactions of effects.

Several issues arise at the effect prediction stage. First, this stage can easily highlight just how little effect a given plan or project has on a given receptor, relative to the sum total of all the effects on that receptor. Many cumulative problems:

- are caused by the accumulation of many actions, not by new plans or projects. The Cheviot Mine project CEA, for example, determined that existing activities had caused most of the

Table 1
Example of intra-plan CEA: a. summary of assessment of individual 'policies' in the Yorkshire and Humber Regional Spatial Strategy, and b. more detailed description of cumulative effects (excerpts from Levett-Therivel and EDAW, 2005)

a.

Sea objective: / RSS policy:	1. Employment opportunities	2. Conditions for business success	3. Education & training opportunities	4. Good health	5. Safety and security	6. Vibrant communities	7. Culture, heritage, leisure	8. Local needs met locally	9. Maximal access, minimal effects	10. Built environment, land use	11. Quality housing	12. Bio-diversity, landscape	13. Minimal pollution levels	14. Greenhouse gas emissions	15. Resource use, waste	(i) Social inclusion and equity	(ii) Partnership & participation	(iii) Adaptation to rural/urban needs	(iv) Creativity, innovation, technol.	(v) Global sustainability
YH1. Overall	++	+	+	+	+	+	+	++	++	0	0	+	+	+	0	I		0	0	0
YH2. Climate change	0	+		+	++	+		+	+	++	+	+	++	++	++				0	++
YH3. Spatial priority	++	++		I		+		+	+			+	+	+		+		+		
YH4. Working together	+	+		+		+		++	+−		I	+	+−	+−		+		+		+−
YH5. Urban focus	+	+	0	+	+	+	+	+	+	+	+	+		+						
. . .		+		+				+	+−	+		+−	+	−	+−					−
Total effect	++	+	+	+	+	+	+	++	+−	+	+	++ −	+	+−	+			++		++ −

b.

Sea objective	Total effect of the RSS policies
12. Bio-diverse and attractive natural environment.	++/− Promoted through policies that protect not also designated sites but also non-designated areas. The Humber Estuary is (rightly) given particular protection. On the other hand, development of ports, airports and associated developments, and other major transport infrastructure is likely to have an adverse effect on biodiversity.
13. Minimal pollution levels if environmental effects are a significant result of the activity consider an environmental effect assessment.	+ Promoted through environmental maintenance and enhancement policies, but not a main focus of the RSS, and potentially counteracted by major development (including transport infrastructure) proposals.
14. Minimise greenhouse gas emissions and a managed response to the effects of climate change. If environmental effects are asignificant result of the activity consider an environmental effect assessment.	+/− The RSS has little/no control over emissions from power stations. The urban focus helps to reduce the need to travel, but proposed transport infrastructure, national government policies, and general lifestyle trends would counter that. The RSS promotes energy efficiency in buildings, but does not go beyond national standards. Generally, the RSS does reasonably well given its limited powers, but is overall unlikely to counter negative trends.
15. Prudent and efficient use of energy and natural resources with minimal production of waste.	+ The RSS promotes renewable energy production, the efficient use of land and the waste hierarchy.

Key: ++ very positive; + positive; 0 no impact; (blank) N/A; I depend implementation; +/− range; − negative; −− very negative.

Table 2
Example of inter-plan CEA: effects of the Yorkshire and Humber Regional Spatial Strategy (from Table 1) plus those of other plans, programmes and actions (excerpts from Levett-Therivel and EDAW, 2005) (see bottom of Table 1 for key)

Cumulative problem	Current status [a]	RSS effect [b]	Cumulative effects of RSS with other plans, programmes and actions [c]
Lifestyles and transport	−−	+/−	−− The RSS focuses on reducing the need to travel and promoting more sustainable forms of transport, although some aspects still support long distance travel (e.g. Leeds and South Yorkshire sub-areas), and air travel. National trends are towards increasing car- and particularly air-based travel, and the RSS is unlikely to change this.
Climate change	−	+/−	− Although the RSS tackles climate change actively, it is unlikely to reverse negative national/regional trends, and climate change targets are unlikely to be met. Transport is a particular culprit both nationally and regionally.
Biodiversity	0	++/−	0 Measuring biodiversity is difficult and contentious. Biodiversity in the region is probably holding roughly steady after a historic downward trend, and the RSS would probably maintain this. Effects on the Humber Estuary could be significant.
Water demand and capacity	−	+	− Water demand is increasing nationally, mostly from households. Some parts of Y+H are already at or near capacity for water provision. The RSS includes a policy on water resources, but this is unlikely to stop negative trends.

[a] The SEA CEA assumed that issues identified as problems in the baseline stage were by definition cumulative effects.
[b] The scores were taken from Table 1. The problems identified in the baseline stage did not all directly correlate with SEA objectives used in the assessment stage. Hence the second column of this table is sometimes an amalgam of several relevant objectives from Table 1.
[c] Brings together columns 1 and 2.

adverse effect on grizzly bears, whilst the proposed mine would have only a modest additional effect; and

- have built up over time, e.g. today's global warming is due to our past actions, and it is our descendants who will deal with the climate effects that we cause.

This could suggest that a proponent only has a relatively limited ability to do anything about a cumulative issue. For instance, Table 2 suggests that, although the Yorkshire and Humber Regional Spatial Strategy would consistently have more positive effects than the general background trends, it is unlikely to significantly change these trends. In turn, this information could be used either as an indicator of the need for a major effects management plan or to justify the case for doing only very little in any one project or plan to reduce cumulative effects.

The "apportionment of blame" problem arises at all scales: plan-makers argue that it is people's individual actions that have the effects, individuals argue that their actions are constrained by government policies, and both blame China's rapid economic growth for pretty well everything. It is used in the management stage to justify not doing much about the cumulative effect.

It may be less of a problem at the project level. Even though a project proponent may contribute only modestly to a significant adverse cumulative effect, proposed projects for which EIAs are done require regulatory approvals. The existence of a significant cumulative effect that

would be made worse means that project approval is at risk. For this reason, the proponent is more likely to make efforts to mitigate the cumulative effect. For instance, cumulative effects meant that the Cheviot Mine project would have difficulty being approved, which led to an attempt to reduce this cumulative effect to an acceptable level. This is, of course the beauty of CEA; it identifies effects in need of more effective management, even for projects not under the immediate control of project (or plan) proponents. In other cases, such as those involving the death of 1000 cuts, it may not make sense to refuse the proposed project, but it may be possible to mitigate projects that contribute insignificant effects in order to reduce the cumulative effect. The role of the CEA in such a case is to identify the need for such cumulative effect management; it is then up to the relevant regulators to use the information. This is one significant benefit of CEAs generally: they identify problems that need attention.

Finally, often only a rough identification of key cumulative effects is needed in order to identify appropriate management measures. However consultants are often reluctant to produce CEAs that are not very detailed, even when broad-brush assessment is appropriate. In the absence of detailed data, they may not discuss an effect at all rather than carry out a 'good enough' assessment. For example, CEA consultants for the Cheviot Mine in Canada had developed a very good vegetation inventory and, with detailed information about future forest harvesting, could have identified specifically which types of vegetation would be affected. This, in turn, would have identified which wildlife habitat would have been affected. But the future forest harvest plans were not available, so the CEA included neither a prediction nor an assessment of these future effects. One can understand the desire of consultants to prepare detailed, sound effect assessments. Reviewers of effect assessment documents are constantly challenging superficial (broad-brush) assessments and demanding greater detail. Impact assessors also see themselves as doing sound scientific predictions and do not wish to tarnish their reputations with anything less. The problem is that by avoiding anything less, they exclude very useful information that is needed by decision makers. In the Cheviot case, the failure to include future cumulative effects led to a judicial review of the decision to approve the project and a rejection of the process leading to approval (Creasey and Ross, 2005). The key is to use the appropriate scale in predicting cumulative effects.

3.2. Does scale matter?

First, one would assume that the greater the spatial extent of the project/plan is, the less detail its CEA would go into. However this is not necessarily the case. In the UK, SEA (there is not yet enough relevant CEA practice) is typically governed by the rule of proportionality: the more detailed the plan is, the more detailed the SEA should be. If a regional-level strategy proposes individual projects, as is often the case, then at minimum the SEA should compare the project against the 'no project' alternatives. In practice, this rule is difficult to apply: Government guidance urges planners to be spatially specific, leaving the SEAs struggling to assess both the plan-wide 'woods' and the project-specific 'trees'.

The scale issue of how wide to cast the net in CEA – the choice of what other human activities to consider in CEA – is difficult. Existing guidance typically refers to past, present and likely future plans and projects, but underlying trends not related to specific plans or projects are often much more significant, particularly at the more strategic level. Project cumulative effects are often dominated by a few major activities: for instance, in the Alberta-Pacific pulp mill case, a few pulp mills contributed so much BOD into the Athabasca River that even the municipalities had a comparatively small effect that could be properly ignored in the CEA (Alberta-Pacific Environmental Impact Assessment Review Board, 1990). In contrast, many more activities are

likely to contribute to the cumulative effects of a plan because of the sheer spatial extent and range of resources affected by the plan.

Project-level CEA predictions are typically made at the same level of detail as the remaining EIA predictions, despite being based on information and assumptions about a much wider range of other activities: they are essentially 'EIA-plus'. In contrast, plan level CEA predictions tend to be more broad-brush and unquantified – more strategic – than the remaining SEA predictions.

The greater temporal extent of many plans and programmes – for instance the emerging Thames Estuary flood management strategy goes to 2100 – means that their CEAs have the potential to identify long-term effects. Certainly many SEAs distinguish between "within the plan period" and "beyond the plan period", and with plan periods typically being 10 years or more, this suggests at least a medium term assessment horizon. In practice, however, even with the opportunity to consider effects into the gloriously distant future, it is often difficult to do so in CEA. In the Thames example, for instance, nothing is known about future development plans for land along the Thames after 2025, and even long-term 'horizon scanning' studies don't go beyond 2075. Different assumptions about energy sources, technologies, population levels etc. can lead to such huge uncertainty and hence such radically different cumulative effect predictions that simple +/− 'predictions' are often the best that one can get and hence are the most useful outcome of a CEA.

Current prediction techniques – typically 'expert judgement' – are unlikely to identify the more subtle cumulative effects, for instance those involving space–time lags, path dependencies, non-linear relationships, positive and negative feedback mechanisms, and critical thresholds. These in turn have scale implications: for instance, new housing may use water abstracted from a reservoir many miles (and multiple local authorities) away; and one authority's mitigation measures could make possible (or impossible) a project in another authority. More complex tools, such as causal chain analysis or modelling, may be needed for this.

Politically, cumulative effect predictions are likely to be less contentious at the strategic than at the project level. At the project level, someone's project is at risk; at the strategic level, because of the more proactive and long-term nature of plans and the more social or sustainable remit of government bodies, there should be less tendency to choose scenarios and assumptions that minimise the predicted cumulative effects.

Nevertheless, it is interesting that the UK Department of Trade and Industry's (2003) SEA CEA of an offshore oil and gas exploration plan did not assess or mitigate for the climate change impacts of the use of the oil and gas because these "are subjects for a different appraisal forum" (n.b. a more strategic one at which SEA is not legally required). This is an example where a limited choice of scale, in the form of temporal limits, can preclude analysis of significant cumulative effects.

3.3. Effective prediction of cumulative effects

In sum, to support robust management measures, robust but efficient effect prediction is required that:

- Is based on reasonable assumptions, for instance about people's future behaviour, technologies, and fuel price and availability. Regulators could greatly facilitate CEA practice by identifying such assumptions;
- Considers long-term as well as shorter-term effects, and does not abbreviate the temporal or spatial horizons so as to miss out key cumulative effects;

- Considers the interaction of the proposed plan or project with a good range of other past, present and future actions (not just projects, as is suggested by the California Environmental Quality Act; and not just intra-plan or intra-project effects as is currently done in most UK SEA CEAs). For near term future activities, those for which good information is available and that are important for the cumulative effect of concern, good prediction of effects ought to be expected. As one gets into the more distant future, only a broad-brush picture of effects is needed, given the uncertainty of these hypothetical futures.
- Considers not just the area as a whole, but also whether any sub-areas will be particularly affected. This is an important scale issue. Although in the Derbyshire example above (see Section 3.1) it is difficult to see why the total effects on a particular road link matter, it is certainly useful to ask whether a specific community is disproportionately affected by development.
- Focuses on getting predictions that are "good enough" and "fit for purpose". A broad-brush picture of effects is *much more useful* than no picture at all.

4. Policy and environmental context of cumulative effects

The context-setting stage of CEA should help to describe the baseline environment, identify causes of any existing effects, give an indication of how severe any existing effects are, and help to identify what organisations need to be involved in managing the effects. The European Commission's (2001) SEA Directive requires information to be provided on both "the relevant aspects of the current state of the environment" and "environmental characteristics of areas likely to be significantly affected". The latter implies a zooming down to provide more detailed information for more affected areas and less attention to components of the environment not affected, a very important scale issue. Typically the baseline would describe environmental conditions in the authority generally, with a table or series of maps providing more detailed information for each proposed development site (e.g. the site's distance to nature conservation areas, whether it is in a floodplain etc.).

4.1. Past practice

One effective approach used in a few UK SEA CEAs is that of "topic papers" related to specific receptors (climate change, biodiversity etc.). Topic papers bring together information on:

- Policies, plans and programmes that affect the specific receptor, and the indicators, targets and thresholds set for the receptor;
- Baseline data on the topic and on the receptor, including information on trends and data gaps;
- Lists of data sources (useful for updating baseline information);
- Key issues and problems arising from the policy context, baseline review and any early consultations; and
- Possible management approaches that could be taken through the plan in question, and other plans, programmes and activities.

The topic paper approach, which reflects the receptor-based emphasis of CEA, is quite different from that typically taken in UK SEAs, which involve describing the policy context for the plan first, then the baseline for the plan, etc.

Several issues arise at this stage. First, the description of the historical build-up of effects is particularly useful in CEA, as it gives an indication of why cumulative effects have arisen and

how they might be managed in the future. The recent US Council on Environmental Quality (2005) memo on how to deal with past actions in CEA is unhelpful:

> "Agencies… look for present effects of past actions that… have a *significant cause-and-effect relationship* with the direct and indirect effects of the proposal for agency action and its alternatives…" (emphasis added)

We believe that limiting the consideration of past actions to those with significant effects on the cumulative effect is wrong, since even insignificant contributions to that effect can be relevant. We agree with Duinker and Greig (2006, p 158) that one can use past actions to mitigate cumulative effects by mitigating "the effects of past and present developments where possible (e.g., lower effluents from existing pollutant emitters)".

In some instances, particularly for project CEA, identifying other organisations and stakeholders relevant for cumulative effects management can be relatively simple. For Canada's Cheviot Mine, the Energy and Utilities Board (the regulator for energy projects, both coal mines and oil and gas projects); the Natural Resources Conservation Board (regulator for forestry projects); Alberta Environment (responsible for the natural areas visited by recreational users) and Parks Canada (responsible for the nearby Jasper National Park) were all responsible for some regulatory aspects of managing the cumulative effects. However in other cases, a vast number of individuals may be involved, the other organisations can be quite far away, and the organisations may even leapfrog other authorities.

4.2. Effective context determination for cumulative effects

In sum, good CEA context determination would do the following:

- Consider past trends and human activities, keeping a broad mind about what these trends might be.
- Use the baseline description to give an understanding of whether there is a cumulative problem or not. The purpose of baseline studies is not just to collect data, but to use the data to understand what is happening. For instance the area of designated land in an authority means little ("we have 42 hectares of woodland in borough *X*"), but information about the following does:
  - trends ("in 1990 it was 13 hectares" is very different from "in 1990 it was 130 hectares");
  - comparison with targets or standards ("50 hectares would be needed to allow long-beaked grouse to be re-introduced");
  - comparison with other areas: "the residents of borough *X* have less than half the area of woodland per person than adjacent boroughs *Y* and *Z*".
- Compare the baseline situation against 'true' targets. Where no targets exist, they should be created. The Quality of Life Assessment approach[6] could be a good way forward;

[6] The Quality of Life Assessment approach (Countryside Agency, 2004) involves first converting any resource (e.g. open space) into the services and benefits that provides for people (recreational and visual amenity, added value for nearby houses etc.), and then asking:

- who does the benefit matter to, why, and at what spatial scale?
- how important is it?
- do we have enough of it?
- what, if anything, could make up for any loss or damage to the benefit?

This can help to identify innovative management measures that better take on board how people actually use the resource. This is roughly the approach that was used to identify management measures for the Surrey Heaths.

- Maps are an excellent way of presenting data at any spatial scale, and help to link different scales of baseline description;
- Other relevant organisations that need to be involved in managing the cumulative effects need to be identified. Non-adjacent authorities could still contribute to cumulative effects; and
- The baseline information, and later the monitoring results after project or plan authorization has been given, should be collected in accordance with monitoring protocols stipulated by the regulators. These protocols should ideally be used by all monitoring programmes in the regions so that the results can be shared for cumulative effects management purposes. The data collected should help government regulators to make best use of the monitoring results.

5. Scoping of cumulative effects

Scoping in CEA involves identifying those receptors that are likely to be subject to significant cumulative effects. At the project level, the idea of "context scoping" was proposed in Canada by Baxter et al. (2001), based on a detailed study of about a dozen CEAs. Context scoping involves first listing all effects of the project under review and then determining those for which cumulative effects can be expected. The CEA would focus only on the latter. Fig. 2 illustrates this idea. A similar approach is likely to work at more strategic levels.

5.1. Past practice

In practice, CEA scoping at the strategic level in the UK still seems to be done in an informal and ad hoc manner. An analysis of 18 UK SEA CEAs[7] suggests that some quite different 'scoping rules' are in use:

- Environmental and sustainability problems identified in the baseline description stage;
- Multiple effects from different parts of the plan, or from the plan plus other actions, identified at the end of the effect prediction stage;
- Everything listed in the SEA Directive, except effects that would clearly not be a problem, plus social and economic factors (not a receiver-based scoping technique);
- No obvious scoping technique or analysis of cumulative effects.

The review of these English CEAs also considered what types of cumulative effects had been identified. Table 3 shows effects identified in more than one of the CEAs. There was consensus at all spatial extents that biodiversity and climate change are cumulative effects. Other cumulative effects listed in several CEAs were transport, waste, water supply, resource consumption, reduction in landscape quality and flood risk. This is probably a very reasonable list, given the pressures faced by a small developed country with a large and relatively affluent population. Several CEAs identified cumulative effects on a sub-set of receivers, for instance effects on nearby communities, on older people. Other 'cumulative effects' identified were:

- in a regional spatial strategy: relative deprivation vis-a-vis other areas, ageing of population, quantity and affordability of housing

[7] Thirty-two 'recommended' SEA reports (Levett-Therivel, 2005) were analysed, plus the SEA for the South East Plan which was known to consider cumulative effects. Of these 33 reports, 18 were for the assessment stage (the rest were scoping reports), which should in theory have included an analysis of cumulative effects. Only nine reports clearly identified the plan/programme's cumulative effects.

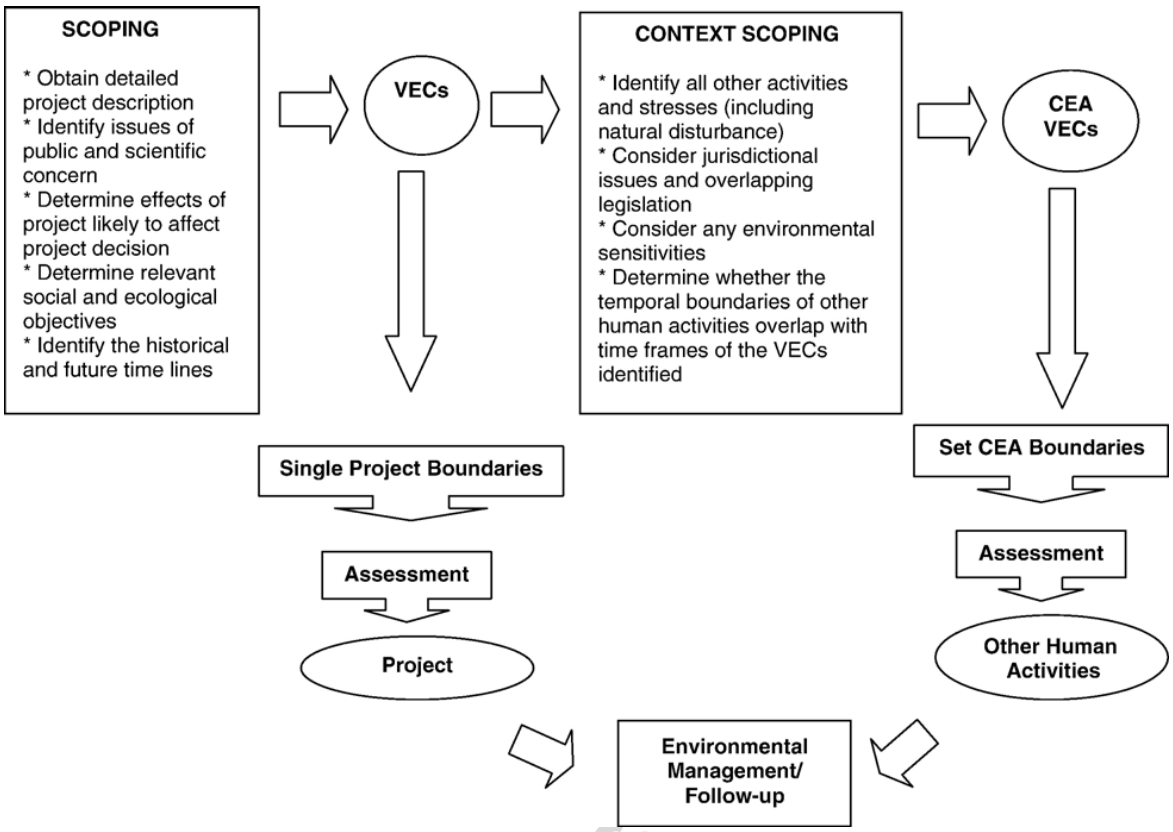

Fig. 2. Context scoping (Adapted from Baxter et al., 2001).

- in local transport plans: severance/accessibility, water quality, soil contamination, human health, noise
- in a plan for offshore oil and gas exploration: underwater noise, physical damage to features and biotopes, physical presence of offshore infrastructure, marine discharges, accidental events

Table 3
Main cumulative effects identified in UK SEAs (number of SEAs for which the effect was 'scoped in' as a cumulative effect)

Scale of plan: cumulative effect identified in SEA/CEA:	Out of 4 regional plans (2 land use, offshore oil & gas, flood management)	Out of 4 local plans (2 transport, land use, waste)	Large site (land use)
Biodiversity, habitat loss	4	4	0
Climate change, energy use	2	4	1
Transport	2	2	1
Waste	2	2	1
Water supply	2	1	1
Resource consumption	2	2	0
Landscape quality	2	2	0
Flood risk/drainage	1	1	1
Land use	1	1	0
Air quality	0	3	0
Cultural/historical heritage	1	2	0
Relative deprivation within area	2	1	0

- in an Area Action Plan for a large site: settlement character, residents' satisfaction, effects on residents in the adjoining villages, provision of infrastructure, viability of facilities in surrounding villages

The most striking finding is that CEA scoping is done poorly, if at all, at the strategic level in the UK. Typically it is not receptor-based. For instance, several SEAs incorrectly defined human activities – accidental events, recycling and composting, 'lifestyles' – as receptors or effects, although they are all activities causing effects. In the absence of a robust, transparent, agreed CEA scoping methodology, scoping can easily be driven by politics as much as by science: economic deprivation or biodiversity can be added to the list of scoped-in effects simply because an economist or ecologist is on the right panel; significant effects can be omitted because it would be politically simpler to do so.

Ross (1998) has suggested that, the larger the area covered by a CEA, the less likely a particular effect is to be identified as being significant, because more other sources of effect get captured in the analysis. This is borne out by the brief analysis of UK CEAs: the regional-level CEAs listed, on average, the same number of cumulative effects as the more local-level CEAs, despite obviously being subject to a wider range of effects. This implies that effects can be 'lost': certainly, any one project's effects are likely to be less 'significant' in a regional-level assessment than in a district- or site-specific assessment. On the other hand, this could simply be seen as representing a very reasonable focus on key issues. It makes sense that, as the spatial scale increases, some more local issues (e.g. noise, townscape) are likely to fall out and others (e.g. climate change, biodiversity) are likely to become more important. In practice, there is no indication that either spatial or temporal boundaries are set so as to constrain scoping: for instance, several SEA CEAs discussed future climate change and flooding issues that went well beyond the plan period.

5.2. Does scale matter?

Hierarchies of policies, plans, programmes and projects do not yet seem to influence CEA scoping. None of the CEAs analysed had explicitly inherited cumulative effects from a higher-level CEA: for instance, none of the local-level plans considered climate change or biodiversity *because* they had been identified as problems in a previous regional CEA. In fact, the same cumulative issue at times took a different slant depending on the spatial scale at which it is analysed. Climate change at the regional level was interpreted as energy use in the more local-level SEAs; flooding at the regional level was 'site drainage' at the site level; relative deprivation between regions became, at the local level, effects on nearby villages.

But should effects be inherited from higher (or lower) levels, and under what circumstances? A particular scale problem lies in the scoping of relative effects. For instance, if a species is rare at a regional level but abundant locally, should that species still be 'scoped in' for CEA at the local level? If water provision is a problem in a region but not locally, should development in the local area be restricted? In Fig. 3, which shows water resources in the Yorkshire and Humber region, should water capacity be identified and managed as a cumulative issue in York, where additional water is available? Maps of relative deprivation in Essex (north east of London) show parts of the county as being relatively deprived; but because some of London's boroughs are amongst the most deprived areas in the UK, any map showing relative deprivation in both Essex and London make Essex's 'deprivation' looks very paltry indeed. So should relative deprivation in Essex be scoped in at the county level but not at the regional level?

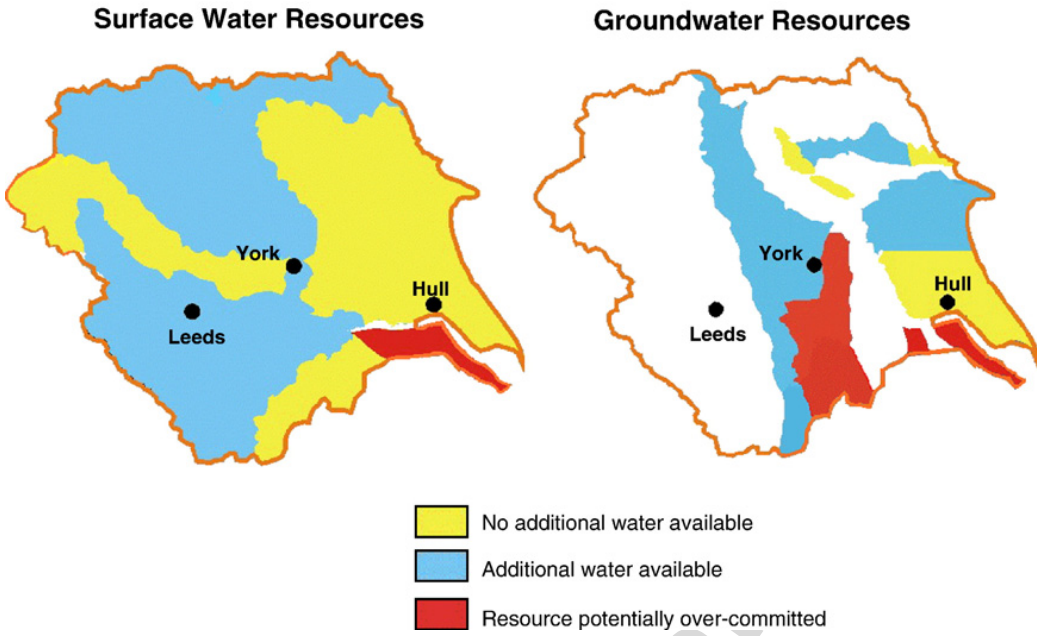

Fig. 3. When is a cumulative problem a problem? Water resources in the Yorkshire and Humber region (Yorkshire Futures, 2005).

5.3. *Effective scoping of cumulative effects*

The issues discussed in Sections 5.1 and 5.2 suggest that good CEA scoping should:

- be carried out using a robust and transparent methodology;
- be environmental resource oriented. It should consider 1. existing cumulative problems (identified at the context-setting stage) and 2. the effects of the project or plan (identified at the effect prediction stage);
- not rely on a list of cumulative effects that should be considered in all CEAs, as effects depend on the local situation and particularly relative effects;
- refer to, and possibly "inherit" cumulative effects and problems identified in CEAs of higher-level policies and plans;
- be adaptable: effects should be able to be added to, and removed from the scoping list as the CEA progresses and the plan/project is fine-tuned;
- pay attention to both temporal and spatial scale and geographical boundaries. Boundaries should be selected based on intellectually sound criteria (such as ecologically determined areas);
- consider issues that are not yet problems but are likely to become so in time, notably climate change and flooding.

6. Conclusions: CEA and scale issues

João (2005) identified several dimensions of scale in SEA: spatial extent, level of detail, and temporal as well as spatial scale. None was particularly well dealt with in the CEAs analysed, either in the methodology used or in the way that the assessment was carried out. As a result, while we have shown examples of CEAs leading to effective management of cumulative effects, this has not occurred as often as it should, in part because of this poor treatment of scale issues. Major limitations included unclear or non-existing methodologies for scoping of cumulative

effects; poor consideration of past or likely future human activities beyond the plan or project in question; attempts to apportion 'blame' for cumulative effects, and claim that a given plan or project can do little to deal with such effects; and, at the plan level in particular, limited management of cumulative effects, caused particularly by the absence of consent regimes.

On the other hand, evidence of 'scale abuse' was limited. One CEA for oil and gas exploration did not consider effects on climate change by claiming a limited remit, but most CEAs did not seem to manipulate scales so as to constrain the consideration of cumulative effects. However, CEAs often felt like last-minute add-ons, and only became important when they triggered management measures that constrained development.

We have shown how scale matters in creating an ability to manage cumulative effects. When the scale of the CEA is properly inclusive, the ability to manage cumulative effects caused by many individually insignificant activities is enhanced. Including these "small" actions is essential for effective CEA.

SEA has been touted as being much better than EIA at considering cumulative effects. SEA does allow for better consideration of larger areas and longer time periods, and hence a wider range of cumulative effects. It also potentially allows for a wider range of management measures covering project siting, phasing, positive 'shadow projects' and demand management as well as rules covering the development of individual projects: it is this last point that will probably become, in practice, SEA's particular strength. Project EIA CEA has the advantage of being linked to consent regimes that can stop the project unless it fulfils certain requirements; although this is also theoretically possible at the SEA level, very few consent regimes apply to plans and policies, and few strategic decision makers will voluntarily constrain their activities so as to unilaterally limit cumulative effects.

These are early days for strategic-level CEA. More research is needed on predicting techniques and associated uncertainty, and how political will and scale choice might affect results found and decisions taken. We expect strategic-level CEA to improve greatly in the next few years. But the severity of many cumulative effects – global warming, plummeting world fish stocks, decline in biodiversity – means that we have to get it right, and fast.

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