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Maximum Allowable Visitor Numbers: A New Approach to Low Carbon Ecotourism Development

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ABSTRACT

This study looked at the off-site impacts of ecotourism by estimating CO₂ emission of visitors visiting three ecotourism providing forests in the UK namely, Cwmcaern, Coed Y Brenin and the New Forest. Also, CO₂ sequestration of those forests was estimated by using data from the UK Forestry Commission and yield table. The estimated CO₂ sequestration and emission were plotted against the number of ecotourists in order to explore the Maximum Allowable Visitor Number (MAVN) per year to those forests. The number of ecotourists beyond MAVN in the graph was used to indicate unsustainable and carbon-intensive nature of ecotourism. The results revealed that the New Forest was unsustainable and carbon-intensive. Cwmcaern was vulnerable to be unsustainable in near future whereas Coed Y Brenin was sustainable. The MAVN concept had been recommended to policy makers, ecotourism practitioners as it could significantly contribute to curb CO₂ emission while safeguarding sustainability issues of ecotourism.

Key words: Ecotourism, sustainability, visitors (ecotourist), policy makers

INTRODUCTION

The confluence of the growth in tourism and an increased environmental awareness has resulted in the rapid growth of ecotourism. International organization such as WWF, the World Bank (Fennel, 1999), UNEP/WTO (UNWTO and UNEP, 2008) supports and promotes ecotourism as a favorable development path. Therefore, increase in the interest of ecotourism essentially is also attributed to the aspiration of more sustainable way of living to the people (WCED, 1987). Ecotourism may be sustainable on the local level (provided that it puts a minimum threat to local ecosystems) but not in larger scale/global scale (Gossling, 1999, 2000). For example, GHGs emission, especially CO₂ emission of travels associated with ecotourism is very significant and considered as the weakness of ecotourism. Concern over ecotourism is that its global emission could rise by three folds by 2035 than the base year, 2005 (UNWTO and UNEP, 2008). Considering its severe effects in coming decades, UNWTO and UNEP (2008) urged for immediate action in their second International Conference on 'Climate Change and Tourism' at Davos, Switzerland in 2007, 'it underscored the need for the tourism sector to rapidly respond to climate change if it is to develop in a sustainable manner'. While ecotourism providing forests sequester CO₂, visitors visiting those forests emit CO₂. If total CO₂ sequestration is surpassed by total CO₂ emission over one year period of time, the forest cannot be environmentally sustainable. The higher the number of visitors, the more CO₂ emission involved. Attempts have so far been made by researchers (Gossling *et al.*, 2002; Schiantez *et al.*, 2007) to indicate tourism sustainability in terms of energy use and GHGs emission. These efforts focused on international tourism, made mainly by flight. However, we have a paucity

of knowledge on the energy use and GHGs emission by domestic ecotourism. In addition, there were no published articles found which define ecotourism sustainability by comparing trade-off between forests' CO₂ sequestration and visitors CO₂ emission. Furthermore, no published articles were tracked which dealt with exploring maximum allowable visitors number to the ecotourism forests. It is assumed that setting up visitor limit in an ecotourism providing forests would be an effective strategy to ensure sustainability. Therefore, the objectives of this research were: (1) to explore trade-off between forests' CO₂ sequestration and visitors CO₂ emission in a year; (2) to investigate the Maximum Allowable Visitors Number (MAVN) that could be used to indicate sustainability of ecotourism. This research, probably the first of its kind, aimed towards exploring ecotourism sustainability with regard to limiting ecotourists' numbers and climate change.

MATERIALS AND METHODS

The basic methodology included estimating carbon sequestration and carbon emission by three ecotourism providing forests from the UK. The research was conducted between June 2008-September 2008, in three forests in the UK namely, Cwmcarn (South Wales), Coed Y Brenin (North Wales) and New Forest (England). Of its total area of 3841.3 ha, Cwmcarn had ca. 75% area under plantation and the remainder 25% were under miscellaneous land use. Coniferous trees occupied ca. 98% (2800 ha) of total plantation area. Coed Y Brenin forest registered more than 10,000 ha of land, of which only 63% areas were covered by forest cover and the rest are under infrastructure and other non-forestry use. Like Cwmcarn forest, most of its plantation area (96%) was covered by the coniferous trees. Meanwhile, New Forest was the largest of all the three forests encompassing approximately 26,000 ha of land where only half of the total areas are under plantation and the rest are under settlement, infrastructure, roads, agricultural land etc. Coniferous and broadleaf stands shares almost equal proportion of total forest cover.

Forest Inventory data from the UK Forestry Commission and Yield model (Forestry Commission, 1971) were used to estimate carbon sequestration. A questionnaire survey was conducted to get basic data about the visitor's travel which were later used to scale up data from the UK FC to estimate carbon emission by the visitors.

Estimating carbon sequestration: Carbon sequestration of the forests was estimated by quantifying the biomass storage potential of the trees in 2007. Depending on the age and the yield class of a species, the Current Annual Increment (CAI) was recorded from the yield model for every species. Finally, the following equation (modified after IPCC, 2003) was used to calculate CO₂ sequestration:

$$\Sigma\text{CO}_2 = \Sigma(\text{CAI} \times d \times \text{BEF} \times \text{Cf} \times A \times 3.67)$$

where, ΣCO_2 = Total CO₂ sequestered in a year by all species in a forest (mg CO₂), CAI = Current annual increment (m³ ha⁻¹ year⁻¹), d = density of species, BEF = Biomass expansion factor (Levy *et al.*, 2004), Cf = Carbon fraction; broadleaf (0.45), conifer (0.42) (Price, 2008), 3.67 = The conversion factor of C to CO₂.

Estimating carbon emission: One procedure for measuring CO₂ emissions is to multiply average emissions per passenger kilometer (pkm) with travel distances (UNWTO and UNEP 2008). CO₂

emission depends largely on type and age of vehicle and fuel. Keeping this in mind questionnaire was designed accordingly. The day of sampling was purposively selected on Saturday and Sundays (weekend). The visitors were interviewed in places where people stays for a while e.g., car park (opportunistic sampling).

Distance calculation: If visitor's main aim of visiting a forest was recreation (primary trip), the distance travelled was primary distance. When the intention of trip was any other thing during which he/she visited nearby forest (secondary trip), the distance covered was 'secondary distance'. In such case the distance from the place of interest to forest was considered. For ecotourists visiting a forest as part of their week-long holiday plan, distance counting system was rather difficult as they could not say the exact traveling distance.

CO₂ emission calculation: Visitors CO₂ emission (mg CO₂) were estimated by this formula:

$$\Sigma c_{ems} = \Sigma D \times FConF \times 0.001$$

where, D = Distance travelled, FConF = Fuel conversion factor of different types of vehicles (Table 1), 0.001 = Conversion factor, kg to megagram (ton).

Calculation of maximum allowable visitors number (MAVN): To explore how many ecotourists and their associated emission will level off forest's sequestration, visitors' number was plotted in X-axis and emission was plotted in Y-axis. In order to find the Maximum Allowable Visitors Number (MAVN), a simulation was made by increasing visitors' number. The resultant carbon emission was plotted in the graph which finally produced 'Visitors' Emission Line (VEL)'. It was assumed that there would be no tree planting initiative in the forest. Therefore carbon sequestration will be unchanged for next couple of years. The total CO₂ sequestration of the forest in a year was plotted in Y-axis and referred as 'Potential Carbon Sequestration Level (PCSL)'. The intersection point between VEL and PCSL was the threshold level of allowable carbon emission beyond which the ecotourism providing forest is carbon intensive. This level had been referred as 'Threshold Carbon Emission Point' (TCEP) at which forest sequestration and visitors emission remain balanced. A line drawn from TCEP point to X-axis, the intersected pointed indicated MAVN. Similarly, CVN indicated current visitor number.

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Statistical analysis: The processed data was displayed using bar chart and subjected to unpaired t-test and ANOVA at $p \leq 0.05$.

Table 1: Fuel conversion factor (FConF) for different vehicles

Vehicles	Fuel	FConF (kg CO ₂ mile ⁻¹)
Private	Petrol	0.3372
Car/van	Diesel	0.3197
Bus	Diesel	0.1434
Train	Diesel	0.0969

Department for Environment, Food and Rural Affairs (DEFRA), 2007

RESULTS

Carbon sequestration: In 2007, the total CO₂ sequestration of Cwmcarn (CC), Coed Y Brenin (COB) and New Forest (NF), respectively was 15,846.74, 49,089.13 and 41,147.82 mg which based on ANOVA was found to be statistically insignificant ($p \leq 0.05$, $F\text{-cal} = 3.96 < F\text{-crit} = 6.94$). The mean carbon sequestrations in these forests, respectively were 5.20 ± 0.10 , 6.26 ± 0.08 and 8.52 ± 0.06 mg ha⁻¹ (Fig. 1).

CO₂ sequestration rate in coniferous and broadleaf trees in these forests were presented in Table 2. Broadleaf in Coed Y Brenin excelled in sequestering CO₂ (11.67 ± 0.10 mg CO₂ ha⁻¹) over all forms of forests. However, the differences between the coniferous and broadleaf trees in all the forests were insignificant based on unpaired t-test ($p \leq 0.05$) (Table 3).

Visitor characteristics: Out of 387 groups (1022 individuals) interviewed, majority of the visitors got forests by private vehicles: Cwmcarn (97%), Coed Y Brenin (93%) and New Forests (80%). In general, the number of long-distance visitors was higher than short-distance visitors. Local people (<40 mile) accounted for less than 8% visits in all forests. Coed Y Brenin and New Forests received nearly half of their visitors from long distance, coming from up to 400 miles. Average round-trip

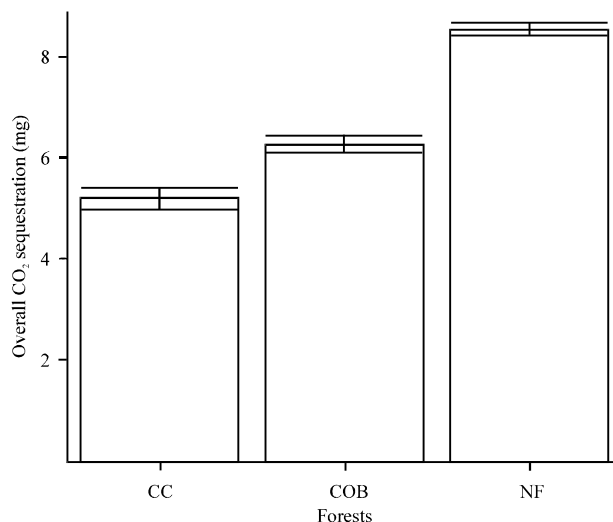


Fig. 1: Mean CO₂ sequestration rate in Cwmcarn (CC), Coed Y Brenin (COB) and New Forest (NF) coniferous and broadleaf trees, error bars show 95.0% CI of mean

Table 2: CO₂ sequestration rate of coniferous and broadleaf trees in the forests under study

	Cwmcarn forest	Coed Y Brenin	New Forest
Coniferous	5.36±0.11	6.47±0.09	7.56±0.06
Broadleaf	2.24±0.69	3.52±0.22	11.67±0.10

Table 3: Unpaired t-test to differentiate between carbon sequestration of coniferous and broadleaf trees of the forests under study

Forests	t-calculated	t-critical
Cwmcarn	0.59	2.44
Coed Y Brenin	1.68	2.77
New Forest	0.76	2.45

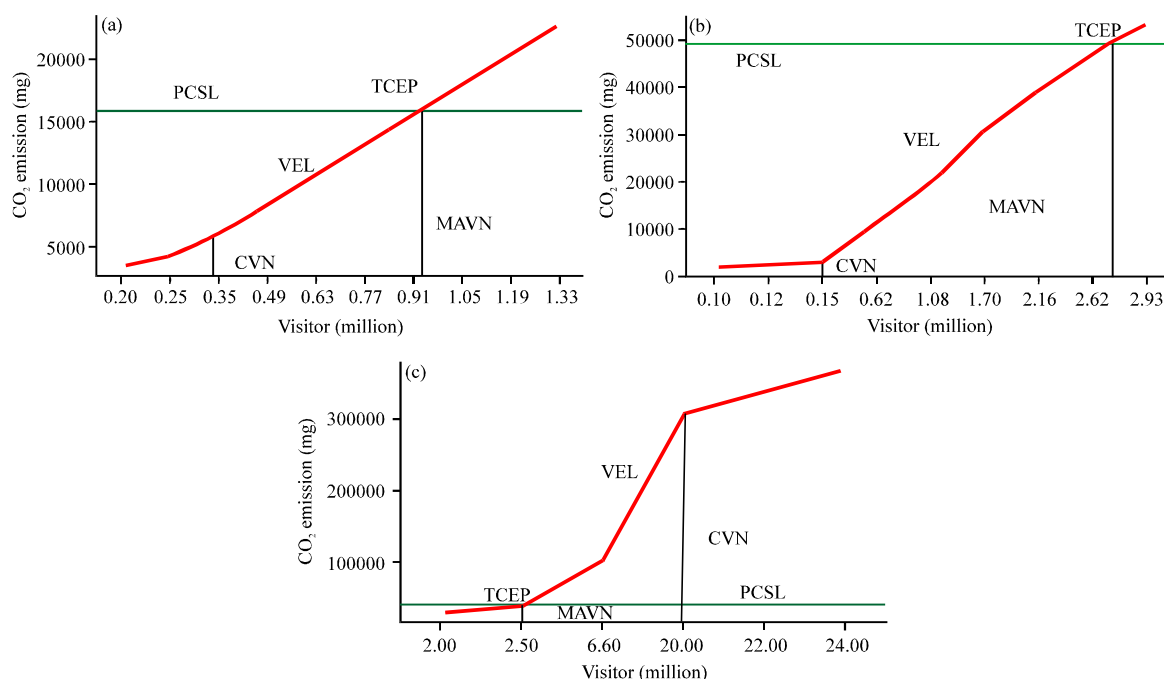


Fig. 2(a-c): Maximum allowable visitor number (MAVN) graph of (a) Cwmcarn, (b) Coed Y Brenin and (c) New Forest, VEL: Visitors emission line, PCSL: Potential carbon sequestration of the forests, CVN: Current visitor number, TCEP: Threshold carbon emission point

distance traveled by each visitor to get Cwmcarn, Coed Y Brenin and New Forest was 52.12 miles, 56.4 miles and 47.30 miles, respectively.

The total numbers of vehicles headed towards Cwmcarn and Coed Y Brenin forests, respectively were 154,460.00 and 58,032.00. On an average, 2.26 and 2.66 number of visitor travel in each private car headed to these two forests. Therefore, the total number of visitors visited in Cwmcarn, Coed Y Brenin, respectively were 0.35 million, 0.15 million. Meanwhile New Forest received 20 million visitors in 2004 which has been taken as proxy for the year 2007. The visitors' numbers had been shown in Fig. 2a-c as 'Current Visitor Number (CVN)' for further analysis.

Carbon emission, questionnaire result: The mean CO₂ emission per visitor in Cwmcarn, Coed Y Brenin and New Forest were 17.14 kg, 18.07 kg and 15.27 kg, respectively.

Total CO₂ emission: The total CO₂ emitted by visitors in Cwmcarn and Coed Y Brenin, respectively were 5,982.34 and 2,790.12 mg. Meanwhile, the total CO₂ emission by the New Forest visitors was 305,454.6 mg. These emission figures had been shown as dotted lines in the Fig. 2a-c and termed as Visitors Emission Line (VEL).

Carbon sequestration of these three forests was shown in horizontal lines (parallel to X-axis) and termed 'Potential Carbon Sequestration Line (PCSL)' (Fig. 2a-c). The intersection point of PCSL and VEL was termed as 'Threshold Carbon Emission Point' beyond which carbon emission was higher than carbon sequestration. At TCEP, there was another important point recorded- Maximum Allowable Visitors Numbers (MAVN). The estimated MAVN of Cwmcarn, Coed Y Brenin and New Forest were 0.92, 2.72 and 2.69 million, respectively. The CVN line of New Forest was on

the right side of the MAVN line signifying higher carbon emission associated with the tourism than the carbon sequestration in the forest. The reverse trend was found for the Cwmcarn and Coed Y Brenin forests (Fig. 2a-c).

DISCUSSION

Of the three forests under study, New Forest was very carbon-intensive and unsustainable. Its' annual carbon emission were 7 times higher than the CO₂ sequestration. This was attributed to very high size of current visitor number (CVN) in compared to MAVN. In particular, CVN in 2008 was ca. 8 times higher than the MAVN. Also, the old-growth broadleaf stands in New Forest were very high (ca. 44%) which had no net gain of carbon sequestration. Meanwhile, the MAVN of Cwmcarn and Coed Y Brenin forest was ca. 3 and 18 times less than the Current Visitors Numbers (CVN).

The UK forests sequestered 2.9 mt C (10.64 mt CO₂) in 2001 and it might sequester 3.2 mt C (11.74 Mt CO₂) in 2010 (Broadmeadow and Matthew, 2003). There are more than 350 million recreational visits per year in the UK (Forestry Commission 2004b). Given each visitor emits 0.0152 mg, the lowest emission of New Forest visitors, total ecotourism related emission could be 5.32 mt CO₂ which is approximately half of total CO₂ sequestration in the UK. Due to global economic recession, number of domestic visitors would substantially increase; this will undoubtedly increase CO₂ emission which could fail UK's sustainable forest management objectives (Forestry Commission, 2004a, b) where it pledges to reduce carbon emission by protecting and expanding forest cover.

Carbon sequestration in most plantations in the UK is 7-15 mg CO₂ ha⁻¹ year⁻¹ (Dewar, 1991). However, the realistic average over a full commercial rotation may be more than 3 mg C ha⁻¹ year⁻¹ (Broadmeadow and Matthew, 2003). The overall CO₂ sequestration rate of Coed Y Brenin (6.26±0.08 mg CO₂ ha⁻¹ year⁻¹) and New Forest (8.52±0.06 mg CO₂ ha⁻¹ year⁻¹) which were not fully mature, fall within this range. Owing to young stand with high amount of trees in low yield class, Cwmcarn showed lower CO₂ sequestration (5.19±0.10 mg ha⁻¹ year⁻¹) than other forests.

CO₂ sequestration was influenced by the yield class and ages. For this study only above-ground CO₂ sequestration was considered. Carbon uptake by forest soils is substantial, 0.5 t C ha⁻¹ year⁻¹ (Postel, 1988) but it is assumed that this could be balanced by C loss from soil (Faeth *et al.*, 1994). In his research on sustainability of tourism development and energy use, Gossling *et al.* (2002) also used the similar kind of assumption. Old-growth trees are in equilibrium with the atmosphere in terms of carbon exchange (Dewar, 1990), hence were not considered in this research. It was assumed that thinned wood will be used for producing long-life products.

CO₂ emission was found varying with number of visitors, their traveling distance, types of vehicles used. Majority of the visitors got forests by private vehicles, Cwmcarn (97%), Coed Y Brenin (93%) and New Forests (80%) reflecting the study conducted by TourismSouth-East (2005). Average round-trip distance in all forests ranged between 47.30 mile (New forest) and 56.4 mile (Coed Y Brenin). Visitor's per capita CO₂ emission for a trip was between 15.27-18.07 kg CO₂, the lowest in New Forest and the highest in Coed Y Brenin. Similarly per capita emission associated with public bus users ranged between 0.93-1.59 kg CO₂ which was 11-16 times lower than private car users. Lower emission rate in New Forest was attributed to the nearness of big city like London. Meanwhile, higher emission rate in Coed Y Brenin was attributed to long distance from the big city like London.

According to UNWTO and UNEP (2008), CO₂ emission for 2 person occupancy cars in high income countries is 0.133 kg pkm⁻¹ (0.214 kg m⁻¹). Considering this emission as appropriate for the visitors in these forests, the visitors in Cwmearn should have emitted 11.15, 12.09 and 10.12 kg CO₂, respectively. In reality, their emission was considerably higher than this. Therefore, like UNWTO and UNEP (2008), this paper also supported the notion of mitigating climate change by curbing CO₂ emission. If energy use related to accommodation, power use and other activities were considered, the emission definitely could have gone higher than this estimate.

Recent global concern over climate change is spearheading development activities in pertinent with sustainable development concept. Sustainable forest management is considered the means of sustainable development in forestry sector. The UK forestry commission also gives priority to sustainable forest management and sinking CO₂ through forest vegetation. One out of three ecotourism providing forests is seen unsustainable in terms of CO₂ balance. Although other two forests are sustainable at this point of time, who knows after 10 year they will also be unsustainable. In case the same fate happen to other ecotourism providing forests in the UK, eco-tourists' emission alone will equalize or surpass carbon sequestration of its forests and woodland. It means the objective of sequestering carbon through forestry to mitigate global climate change will fail. All efforts in this regard will be futile and meaningless. The dual objectives, providing recreation (ecotourism) and carbon sequestration will become competitive and hostile to each other. Also ecotourism will be a matter of sorrow rather than blessings. In that situation forestry will be a source rather than sink.

This could be reminded that increasing CO₂ sequestration is more uncertain than increasing intensity of visits by ecotourists or visitors groups. Besides forest has its own limit of sequestering CO₂ from the atmosphere. It is also reminded that imposing carbon tax could also not be permanent solution; rather it will be temporary solution of permanent problem. Therefore, it could be logical to limit recreational visits based on the Threshold Carbon Emission Point (TCEP).

Increasing energy efficiency of private vehicles, using bio-fuels or combination of solar energy, hydrogen and fuel cells could be better option. Restricting access of cars with old technology in favor of cars with new technology could also be very good option that has been successfully experimented by villages in Alps (UNWTO and UNEP, 2008). Encouraging visitors to travel by public transport could probably be the best option in reducing emission level.

Once MAVN per year are set, the recreation manager could declare this number to the media or its website. 'The first come first serve' could be the motto to allow entrance to the forest for recreation. Prior registration over telephone or online could be helpful to book a visit in the forest. In addition, creation of new recreational forests could substantially reduce the traveling distance as well as related CO₂ emission.

For example, New Forest's Current Visitor Level (CVL) was almost 7.5 times higher than its MAVN; therefore it could be regarded as unsustainable and carbon-intensive tourism providing forest. While Cwmearn was vulnerable to show unsustainability in near future, Coed Y Brenin was stable.

CONCLUSION

It is concluded that international community should try to make the global forest sector carbon neutral in coming decades whereby emissions from forest loss is balanced by forest growth. Given that the forestry sector follow sustainable forest management, it will still struggle to ensure carbon neutral sector as there are still carbon emission associate with visits to forest in search of recreations

or wilderness. The potentiality of this approach is that if followed properly it could contribute to sustainable and carbon neutral ecotourism which could subsequently curb national or global greenhouse gases (GHG's emission). This concept could also be considered a viable option to climate change adaptation. In addition, this concept could complement on-site sustainability indicators e.g. ecological carrying capacity. Furthermore it reconciles ecotourism and forest management towards attaining the goal of sustainability, therefore, highly recommended to the policy maker for the adoption and application.

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REFERENCES

- Broadmeadow, M. and R. Matthew, 2003. Forests, carbon and climate change: The UK contribution. Forestry Commission, Edinburgh. [www.forestry.gov.uk/pdf/fcin048.pdf/\\$FILE/fcin048.pdf](http://www.forestry.gov.uk/pdf/fcin048.pdf/$FILE/fcin048.pdf)
- DEFRA, 2007. Guidelines to Defra's GHG conversion factor for company reporting-annexes. Department for Environment, Food and Rural Affairs, June 2007, <http://archive.defra.gov.uk/environment/business/reporting/pdf/conversion-factors.pdf>
- Dewar, R.C., 1990. A model of carbon storage in forests and forests products. *Tree Physiol.*, 6: 417-428.
- Dewar, R.C., 1991. Analytical model of carbon storage in the trees, soils and wood products of managed forests. *Tree Physiol.*, 8: 239-258.
- Faeth, P., C. Cort and R. Livernash, 1994. Evaluating the Carbon Sequestration Benefits of Forestry Projects in Developing Countries. World Resources Institute, Washington, USA.
- Fennel, D.A., 1999. *Ecotourism: An Introduction*. Routledge, New York.
- Forestry Commission, 1971. Forest management tables (metric). Forestry Commission Booklet No. 34. Forestry Commission, Edinburgh.
- Forestry Commission, 2004a. Sustainable Forestry in Brief-Social and Environmental Benefits of Forestry. Forest Service, Edinburgh. [http://www.forestry.gov.uk/PDF/fcib002.pdf/\\$FILE/fcib002.pdf](http://www.forestry.gov.uk/PDF/fcib002.pdf/$FILE/fcib002.pdf)
- Forestry Commission, 2004b. The UK forestry standard, the government's approach to sustainable forestry management. Forest Service, Edinburgh.
- Gossling, S., 1999. Ecotourism: A means to safeguard biodiversity and ecosystem functions? *Ecol. Econ.*, 29: 303-320.
- Gossling, S., 2000. Sustainable tourism development in developing countries: Some aspects of energy use. *J. Sustainable Tourism*, 8: 410-425.
- Gossling, S., C.B. Hansson, O. Horstmeier and S. Saggel, 2002. Ecological Footprint Analysis as a tool to assess tourism sustainability. *Ecol. Econ.*, 43: 199-211.
- IPCC, 2003. Good Practice Guidance for Land use, Land-Use Change and Forestry. Institute of Global Environmental Strategies, Hayama..
- Levy, P., S.E. Hale and B.C. Nicoll, 2004. Biomass expansion factors and Root: Shoot ratios for coniferous tree species in Great Britain. *Forestry*, 77: 421-430.

- Postel, S., 1988. A Green Fix to the Global Warm-Up. World Watch Institute, Washington.
- Price, C., 2008. Carbon Fraction of Broadleaf and Conifers. SENR, Bangor.
- Schiantez, K., L. Kavanagh and D. Lockington, 2007. Concepts and Tools for comprehensive sustainability for tourism destinations: A comprehensive review. *J. Sustainable Tourism*, 15: 369-389.
- TourismSouth-East, 2005. Visitor survey of the new forest national park 2004-2005. TSE Research Report, Eastleigh.
- UNWTO and UNEP, 2008. Climate Change and Tourism-Responding to Global Challenges. WTO and UNEP, Madrid, ISBN: 978-92-844-1234-1.
- WCED, 1987. Our Common Future. Oxford University Press, Oxford.