Trial Rapid Assessment of Climate Regulation Services Offered by Three Important Bird Areas in the Trans-Boundary Polessie Area of Eastern Europe and the Influence of Future Conservation Changes on These Services.

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Introduction

This report is intended to summarise, and sit alongside, the separate reports prepared by the authors listed above for the three sites covered. The constituent individual reports and datasheets are contained within the supplementary material as appendices.

Natural habitats are conventionally conserved for their biodiversity and amenity value. Increasingly, however, their value for other services to human populations is being recognised, and quantified, in response to continued threats and undervaluing (in societal and financial terms). These so-called 'ecosystem services' are gaining traction beyond the nature conservation community with both the wider public and with decision makers. It is in this context that a number of rapid assessment tools have been developed to aid conservationists in bringing these diverse and often huge services to the attention of business and governments in support of conservation aims (Peh et al (2013), Mulligan et al (2010), Silvestri & Kershaw (2010), Tallis & Polasky (2011)). Usually these tools attempt to use published, scientifically robust physical and financial values or models to compare the services offered by natural or semi-natural land-uses in comparison with alternative (often threats) land-uses to compare the societal and private costs and benefits of each. It is the comparative nature of these assessments that give them their power, since the estimation of absolute total values of services is often fraught with inaccuracies of measurement and 'appropriateness'. Comparative values of services across different land-use states on a 'level playing-field' allows assumptions to be made about accuracy and applicability of meta-analyses to make valid projections of comparative worth.

Aims

To use the global climate regulation section of the CCI ecosystem service rapid assessment toolkit (TESSA – Peh et al., 2012). This has involved assessment of carbon stocks and greenhouse gas fluxes on representative sites for both the current state (pristine or near-pristine) and the most likely potential alternative state, if these sites remain un-protected or loose their protection. The sites include upland forests, natural and degraded peatlands, river floodplain with riparian forests and natural and degraded open wetlands. The sites have been chosen for their climate relevance, conservation value and need for protection.

Methods

In the assessments of Climate Regulation Services offered by the three sites studied, we have followed the rational and methods of Peh et al. (2012) - 'Toolkit for Ecosystem Service Site-based Assessments (TESSA)'. For each site, we have assessed the current state of the habitats and land-uses, and compared these to the most likely alternatives of these should current site protection regimes be altered, and local most pertinent threats either increase or decrease. We have then compared the climate regulation consequences of such changes in management or exploitation.

Sites & Scenarios

1. **Chyrvony Bor (56° 04'N, 28° 34 'E)**

Description: Chyrvony Bor is situated in the north of Belarus, in the Rasony district of Viciebsk region. It is a huge forest (36 065 ha) with a mosaic of raised bogs, lakes, transitional mires and fens. The peatland area is 9,302 ha. The eastern and western boundaries of the reserve extend along two medium-sized rivers Nishcha and Svol'na. Sebezhsky Regional Park in Russia adjoins the northern boundary. Due to the large waterlogged area and poorly developed road network, the site is impacted little by people. Forest landscapes cover 82 % of the area. Old spruce and pine forests are dominant habitats (Table 1). Most of the wetlands are raised bogs. The main human activities are forestry and hunting. The site is an IBA named Čyrvony Bor http://www.birdlife.org/datazone/sitefactsheet.php?id=26878. And a governmental landscape Reserve

Habitats	**Area (ha)**
Dry coniferous forests	17,568
Dry deciduous forests	6,798
Peatlands	1,897
Forested peatlands	5,959
Total	**32,222**

Table 1. Areas of major habitat types at Chyrvony Bor, Belarus

Threats: Much of the area is in near natural condition, reflected by the above-mentioned valuable and diverse un-drained peatlands. However, the forestry activities have altered the forest structure severely. Interviews with the local foresters have revealed intensification of forestry is likely to be a serious threat for habitats in the area, as well as for the carbon stocks and sinks in the site.

Scenarios: Two possible development scenarios were assessed for this site:

1. The **Baseline** scenario assumes the **continuation** of **intensive forestry**. The planned intensive forestry rotation of cutting and replanting will continue. For this scenario it is assumed that herbal vegetation types will not change substantially over the next 30

years. Currently, a large proportion of the site is under commercial forestry management. 2,300ha have been cut and re-planted in the last six years and a further 7,700 hectares are scheduled for felling over the next 20 years. Harvested wood is used for furniture production and therefore sequestered carbon in forest products is considered to remain sequestered during the project period. Herb and shrub development in regenerating forest blocks is not considered in stock and flux estimates here, due to lack of detailed information, suitable emissions factors and the relatively small size of these factors compared to forestry growth.

2. The **Alternative** scenario **increases site protection**. Cutting of trees will cease and increased protection and conservation management will prevail.

2. Desna River Valley (52° 18′ N, 33° 23′ E)

Description: The project site is in northeast Ukraine, spanning the border between Sumsk and Chernigiv regions. The study area is approximately 30 km long and between 2 and 10 km wide, totalling an area of around 12,000 ha. The river valley is asymmetric, the western river banks rise to 40-45 m, whilst the eastern rivers terraces are more low lying, at between 8 and 15 m. The river valley is broad, with many arms, oxbow lakes, meadows, peatlands and small areas of wet forests. It is one of the biggest conservation sites on the river Desna in Ukraine and is part of the transitional and buffer zone of the ‘Desnianski’ conservation area. The eastern (left) bank is in the 'Desniansk-Starogutsk' National Park. The project site is within the National Park and the 'Desna River valley' Ramsar site. There are a number of zapovednik (no disturbance) zones within the project area and two hydrological conservation areas; the nationally important governmental conservation area of Muravevskaya (40 ha of oxbow lakes around Muravi village); and the local hydrological conservation area of Sinove (8 ha of eutrophic peatlands with grassy and shrubby forestlands in the valley of the River Sudost, around the village of Gremiach. The project area contains two small villages (Muravi and Kolos), with less than 20 permanent inhabitants. Along the national park boundaries there are several larger villages, including Gremiach, Kamenskaya Sloboda, Kamen, Pusharki, Leskonogi, Novovasilievska, Ochkina, Zhuravka and Borovichi.

Threats: The area of Ukraine in which this project site, and the wider IBA, is situated is sparsely populated, and the future population is likely to continue falling. The pressure on the land from human intervention is low and is currently unlikely to change. The scenarios developed reflect this, with on small changes in the distribution and areas of main habitats, largely due to possible changes in grazing pressure.

Scenarios: We identified three different future land use scenarios for this site, as follows (Table 2):

1. The **Current Situation** will pertain, with a mixture of **low level agricultural usage** (mainly rough grazing of wet meadows - 2240 cows, diet 40% concentrate, 60% coarse fodder), **land abandonment** following the closure of collective farms more than 20 years ago, and **strict protection (Zapovednik)** of some small areas. The vegetation communities current will remain approximately as they are now, with some continuation of scrub and low forest regeneration as a result of the relief of previously higher grazing pressure. Typical lowland river vegetation covers less that 20 % of the water surface, mainly on the riverbanks. Oxbow lake communities are dominated by *Nuphar lutea* and *Nymphaea candida* in wet areas, and *Rorippa amphibia*, *Sagittaria sagittifolia*, *Butomus umbellatus* in drier areas. Surrounding these are areas of wet floodplain meadows (*Carex acuta*, *Phalaroides arundinacea*, *Glyceria maxima, Poa pratensis*, *Festuca rubra*, *Alopecurus pratensis)* and drier meadows *(Festuca rubra*, *Poa angustifolia*, *Agrostis gigantea*. *Carex praecox*, *Calamagrostis epigeios*, *Agrostis giganthea)*. Natural deciduous forests, mainly wet in character and of natural or semi-natural structure, are composed of *Quercus robur*, *Fraxinus excelsior*, *Tilia cordata*, *Populus tremula*, *Ulmus carpinifolia* and *Alnus glutinosa*. Plantations of *Populus nigra*, *Populus deltoids* and *Robinia* are found on smaller areas between the river channels, as well as along roads. *Pseudoacacia* spp. have been planted to prevent erosion of the river banks. There are also some plantations of *Pinus sylvestris*. Encroachment of abandoned grazing areas by *Betula pendula* and *Pinus sylvestris* is widespread. Eutrophic peatlands are found beyond the floodplain on the areas between the river channels with communities of shrubby sedge reeds. Peaty meadows with *Deschampsia cespitosa* and *Festuca rubra* are found on drained peatlands. There is a small wild mammal fauna of approximately three moose and 15 wild boar.

Table 2 Major habitat areas in the Desna River Valley, Ukraine, at present and under two possible alternative land-use scenarios.

Habitat	Area (ha)		
	1. Current situation	2. Increased protection	3. Increased exploitation
River beds	678	678	678
Oxbow lakes (wet)	862	862	862
Oxbow lakes (dry)	326	326	326
Wet meadows	1,825	80	2,028
Moist floodplain meadows	6,685	6,685	4,653

Moist upland meadows	109	52	32
Dry floodplain and upland meadows	99	0	2,207
Deciduous moist forest	533	533	533
***Alnus glutinosa* forest**	376	645	376
deciduous plantation	183	183	183
Coniferous plantation	259	259	259
Abandoned fields	858	0	858
Villages	110	110	110
Eutrophic peatlands	30	0	30
***Salix cinerea* scrub**	325	1829	122
***Salix triandra* scrub**	361	166	361
***Salix acutifolia* scrub**	21	0	21
***Salix alba* & *S. fragilis* forests**	275	492	275
Small-leaved forests	46	1,061	46
Buildings	6	6	6
Peaty meadows	285	285	285

2. A **higher protection** (zapovednik) regime allowing natural processes of vegetation succession to proceed. Wet meadows will overgrow with *Salix cinerea,* drier floodplain meadows will be overgrown by small-leaved tree species dominated by *Populus tremula and Betula pendula*, dry meadows outside the floodplain will be colonised by *B. pendula*. Alder carr will increase at the expense of areas of *Salix cinerea* shrubs. Abandoned fields will be overgrown by *B. pendula* and *Pinus sylvestris*. On the boggy meadows peatland plant communities and *Salix cinerea* shrubs will spread. The protection state will have no influence on the farms in the area (2240 cattle). The wild animal stocks will increase to six moose and 45 wild boar.

3. An **increase in grazing**, to regain the intensity of former collective farms. The changes will mainly take place on grassland and scrub areas. Parts of the *Salix cinerea* shrubs will be cut and transformed into grazed wet meadows. The area of dry meadow will increase at the expense of wetter grassland, to improve grazing. The number of cattle will increase by 1000 but the fodder ratio will remain the same. The species composition and areas of forests will not change significantly. The stock of wild animals decreases to one moose and 15 wild boar.

3. Usoditsa (55°13'N, 31°09'E)

Description: The site is located in south-western Tver region. It is located in the western part of the Western Dvina depression between 175-200 m elevation. The predominant soils are sod-podzolic, peat-podzolic and peat (Geography of Tver region, 1992).

The main habitats are coniferous, broadleaved and mixed forests and open and forested wetlands. The 'Usoditsa-Ozernoe-Smorun' lake-peatland complex is made up of huge bogs, some transitional peatlands and wet grey alder forests. Riparian and littoral woodlands are dominated by black alder. The dominant vegetation on bogs is pine-cotton grass-Sphagnum communities. The herb layer is mainly dominated by cotton grass (*Eriophorum vaginatum*), *Chamaedaphne calyculata*, bog rosemary (*Andromeda polifolia)* and cranberry (*Oxycoccus quadripetalus* Gilib.). Bog margins are covered by birch forests with fragments of sedge, sedge-marsh cinquefoil, Sphagnum and pine and birch moss forests. Wet birch forests with willows (*Salix cinerea* L.), wood horsetail (*Equisetum sylvaticum),* and *Shagnum squarrosum* are also present. The area is gazetted as three nature conservation areas: State nature conservation area 'Boloto Ozernoe' (2622 ha), 'Boloto Usoditsa' (3404 ha) and 'Boloto Smorgun' (1566 ha).

Threats. Currently there is low utilisation pressure on the investigation site, comprising small-scale wood cutting to supply local villages, locals berry harvesting, hunting and fishing. In the early 1980's a peatland drainage network was installed around the margins of some bogs, with the intention of extracting peat for fuel, but this was abandoned on the formation of the nature reserve complex. The laws that protect the reserves currently are not so strict that peat extraction could not resume, so our scenarios reflect this.

Scenarios: Two possible future scenarios have been identified at Usoditsa (below) but these involve major management changes rather than relative changes in land-use areas (Table 3):

1. **Current situation** of small scale wood extraction, hunting and foraging.
2. **An increase of nature conservation protection**, in which currently subsistence grazed grassland areas around villages become forested. Forests currently in early succession dominated birch, alder and aspen will become dominated by pine (Antonova &Tyusov, 2007; Isaev et al., 2005; 2008; Smirnova et al., 2006).
3. An **increase in anthropogenic pressure** in form of **peatland drainage and peat extraction.** We assume that forestry activities will stay similar to the current situation with little change in vegetation cover, Peat extraction would occur over an area of approximately 6,000 ha. Drainage of these areas for extraction will affect the water table, and riparian scrub will succeed to deciduous woodland.

Habitat	Area (ha)
Coniferous forests	1,302
Mixed forests	3,935
Broadleaved forests	548
Shrubland	149
Forested peatlands	1,760
Peatlands	5,938
Grasslands	731
Water bodies and rivers	445
Total	**14,809**

Table 3 Major land use areas at Usoditsa, Russia

Fluxes and Pools Assessment methods

Carbon Storage: For carbon storage we assessed the following organic carbon pools in all habitats in the project sites: Above ground living biomass, below ground living biomass, litter and deadwood and soil.

At Chyrvony Bor, we used local forestry inventories to assess yield class coverage of the tree species in natural and semi-natural forests, and assessed the carbon stock by converting tree stock volume to dry matter, using the Carbon fraction of aboveground forest biomass of 0.47 t C/t dry matter (IPCC, 2006). We used the above ground:below ground biomass conversion factor of 0.29 for forest habitats from IPCC (2006). Litter carbon stocks in deciduous and coniferous forests were estimated using values of 39 and 55 tonnes carbon per hectare respectively (IPCC 2006). For the above and below ground biomass figures for peatland habitats, we used the default values of 101 and 18 t dry matter/ha respectively from Anderson-Teixiera & DeLucia (2010). At this site, we did not assess soil carbon stocks, because they are unlikely to change between the scenarios.

We used similar methods at Usoditsa (Table 5), calculating forest aboveground biomass from the Tver forest inventory (2010) and the IPCC (2006) carbon fraction factor as above. Below ground biomass was calculated as above. For litter and dead wood stocks, we used the IPCC (2006) default values of 0.55, 0.39 and 6 tC/ha for coniferous forests, deciduous forests and grasslands respectively. Carbon stocks in peatland soils were taken from the Peat Cadastre of the SSSR (), and for shallow peat soils a default of 369 t/ha (Anderson-Teixiera & DeLucia 2010) was used.

For the Desna River Valley, we assessed both above and below ground biomass and soil carbon stocks (Table 4). For living biomass and litter stocks, we used published values from

Table 4. Living and dead/litter biomass carbon stock factors used for carbon stock estimation at the Desna River Valley, and their source references. *includes litter and dead wood

	AGB	AGB:BGB ratio	BGB	Total t/ha	Total C t/ha	References
Wet meadows	3.4 - 5.04	1:1.25	4.03 – 6.05	7.43- 11.09	**3.715 - 5.545**	Balashov et al 1988
Moderately moist floodplain meadows	2.94 – 3.36	1:2	5.88 – 6.72	8.8 – 10.1	**4.4 - 5.05**	Balashov et al 1988
Moderately moist upland meadows	1.2 – 1.4	1:3.33	4.1 – 4.9	5.3 – 6.4	**2.65 - 3.2**	Balashov et al 1988
Dry floodplain and upland meadows	0.7 - 1.0	1:4	2.9 – 3.9	3.7- 4.9	**1.85 - 2.45**	Balashov et al 1988
Deciduous moderately moist forest	168*	3.5:1	48.7	216.8	**108.4**	S. Panchenko (pers. comm.)
Alnus glutinosa forest				39 -50.1	**19.5 - 25.05**	Field measurement, Valetov et al (1985).
Anthropogenic deciduous forests	168*	3.5:1	48.7	216.8	**108.4**	S. Panchenko (pers. comm.)
Anthropogenic coniferous forests,	114.1*	3.5:1	33.1	147.2	**73.6**	S. Panchenko (pers. comm.)
Eutrophic peatlands	1.7 – 2.5	1:3.5	0.5 – 0.7	2.1 – 3.2	**1.05 - 1.6**	Balashov et al 1988
Salix cinerea shrub	2.4		2.4	4.8	**2.4**	S. Panchenko (pers. comm.)
Salix alba & *S. Fragilis* forests	86.8*	3.5:1	25.2	112	**56**	S. Panchenko (pers. comm.)
Small-leaved forests	96.7*	3.5:1	28.1	124.8	**62.4**	S. Panchenko (pers. comm.)
Peaty meadows	8.8 – 10.1	1:2	17.6 – 21.2	26.5 – 31.2	**13.25 - 15.6**	Afanasiev et al., 1981

Dubyna (1993) Balashov et al. (1988), Valetov et al. (1985), Shvidenko (2008), Afanasiev et al. (1981), Bulohov (2001), Cherchenko (2003) and grain harvest of Bovgorod-Severski region in 2012 (Table 4). Field data were collected using methods from Peh et al 2013. Soil Carbon stocks in the first 20 cm of soils were taken from (local unpublished values (S. Panchenko pers. comm..)(Table 6)

Habitat	**Carbon in fraction (tC/ha)**					
	AGB	**BGB**	**Litter/Dead wood**	**Soil**	**Total**	**Total CO_2 tCO_2/ha**
Coniferous forests	35.2	4.2	0.55	115	155	**569**
Mixed forests	51.2	6.1	0.39	118	176	**646**
Broadleaved forests	51.6	6.2	0.39	103	161	**591**
Shrublands	48.0	4.8	6.0	153	255	**936**
Forested peatlands	17.3	2.1	0.2	101	121	**444**
Peatlands	101.0	18.0	-	369	488	**1,791**
Grasslands	2.3	14.0	6.0	200	224	**822**

Table 5. Carbon stock values for biomass and soil used in the estimation of carbon storage in habitats at Usoditsa, Russia.

Habitat	Bulk Density g/cm³	Soil Organic Matter %	Decomp-osition of peat %	Soil Organic Matter t/ha	Soil Organic Carbon t/ha	Soil CO_2 content t/ha
Wet meadows	0.26	-	40	208	104	**382**
Moderately moist floodplain meadows	1.5	3	-	90	45	**165**
Moderately moist upland meadows	1.5	2.5	-	75	37.5	**130**
Dry floodplain and upland meadows	1.5	2	-	60	30	**110**
Deciduous moderately moist forest	1.5	3	-	90	45	**165**
Alnus glutinosa forest	0.23	-	20	92	46	**169**
Anthropogenic deciduous forests	1.5	2.5	-	75	37.5	**130**
Anthropogenic coniferous forests,	1.5	2	-	60	30	**110**
Abandoned fields	1.5	1.5	-	45	22.5	**83**
Eutrophic peatlands	0.15	-	35	105	52.5	**193**
Salix cinerea shrub	0.23	-	25	115	57.5	**211**
Salix alba & *S. Fragilis* forests	1.5	3	-	90	45	**165**
Small-leaved forests	1.5	3	-	90	45	**165**
Peaty meadows	0.26	-	40	208	104	**385**

Table 6. Soil Carbon content factors and their calculation, used in the estimation of carbon storage at the Desna River Valley, Ukraine.

Gas Fluxes: We assessed the greenhouse gas fluxes into and out of all major habitats in each site under current and projected scenario states. All fluxes were taken from published values. These are expressed as both tonnes of gas emitted or taken up per hectare, and also converted to CO_2 equivalents, after Forster et al. (2007) where 1 tonne of methane has the equivalent global warming potential over 100 years (GWP_{100}) of 25 tonnes of CO_2. At all sites, nitrous oxide fluxes were assumed to be small, and relatively unaffected by land-use changes, so were ignored in this assessment. In this way, we present total net GWP_{100} for each site under each scenario comparatively in tonnes of CO_{2eq}. We use the standard convention of transfer of gas to the atmosphere as positive values, and uptake by biotopes as negative.

At all three sites, we used the Greenhouse Emissions Site Types (GESTs) vegetation proxy method of Couwenberg et al. (2011) to assign emissions factors to all peatland vegetation communities, including those underlying forests (Table 9). These include both drained and un-drained peatlands under both natural and anthropogenic plant communities. GEST GWP_{100} factors were used for organic soils at all three sites, but were supplemented with sequestration values for raised and transition mires at Usoditsa, calculated as per Peh et al. (2012) to compare with mineral soil sequestration factors. Soil fluxes from forests on organic soils were balanced with sequestration from trees. Fluxes due to emissions of uptake by mineral soils are likely to be small in comparison to peatlands and vegetation, and so were neglected in our assessments at Chyrvony Bor and Desna River Valley, but accounted for at Usoditsa using default sequestration values from Anderson-Teixiera & deLuica (2010). Tree sequestration rates were taken from local forestry yield tables (Shvidenko, 2008; Miroshnikov et al., 1980) and converted from stock volume increase rates to biomass and therefore above- and below-ground dry matter accumulation with bark using to the coefficients of Alexeyev et al. (1995) and Alexeyev & Birdsey (1998). Table 7 shows the mean sequestration factors used for the dominant tree species/yield class/densities in forests at each site.

Dominant tree species	**Sequestration (tCO_2/ha/y)**		
	CB	**DRV**	**US**
Alnus glutinosa (50 years old, yield class I)	7.5	4.62	4*
Pinus sylvestris (60 years old, yield class I)	6.82	5.95	6.6
Quercus robur (60 years old, yield class I)		11.11	
Betula pendula (50 years old, yield class I)	14.5	6.57	10.1**
Populus tremula (50 years old, yield class I)	5.73	6.17	7.2*
Salix alba, *S. fragilis* (45 years old, yield class I)		6.41	
Alnus incana, *Salix cinerea* and others years old, yield class I	2.04		
Picea abies (60 years old, yield class I)	19.1		

Table 7. Mean sequestration factors used for the dominant tree species/yield class/densities in forests at the three study sites. DRV = Desna River Valley; CB = Chyrvony Bor; US = Usoditsa. *= Yield class II; **=70 years old.

Species	**Emissions (kg CH_4/head/y)**
Cattle	57
Moose	31
Wild boar	1

Table 8. Emissions factors for enteric methane emissions from animals, used for GWP_{100} estimations at the Desna River Valley, Ukraine.

Methane fluxes due to enteric fermentation in domestic and wild grazers in the Desna River Valley were assessed using the emissions factors from IPCC (2006) for cattle (other cattle) and from Crutzen et al. (1986) for moose and boar (Table 8). No domestic grazers are present in the Chyrvony Bor project area and there is insufficient information on wild mammals, so these were ignored in this study.

	Emission value [t $CO_{2\ eq}$ /ha/y]				
	CO_2	**CH_4**	**GWP_{100} estimate**	**Sites Used**	**Vegetation covered**
GEST					
Moist bog heath	12.5	negligible	**12.5**	CB	Sparse pines with scrub & sphagnum;
Wet *Sphagnum* lawn	negligible	5	**5**	CB, US	Cotton grass and shrubs with *sparse Pinus sylvestris* layer; Cotton grass, sphagnum, scrub Hummock-hollow-carpet complexes; Sedge, grass, sphagnum with sparse birch or willow layer; Sedge, cotton grass sphagnum carpets;
Moderately wet *Sphagnum* hummocks	negligible	0.5	**0.5**	CB	Sphagnum hummocks with scrub, with or without *Pinus sylvestris* layer
Very wet *Sphagnum* hollows	negligible	12.5	**12.5**	CB	Sphagnum, scrub complexes with open pools or many hollows
Very moist bog heath	9	1	**10**	CB	Pines with scrub or heath with cotton grass, sphagnum, heather
Bare peat	7	0.5	**7.5**	CB	
Wet reeds and sedge fens	-4	12.5	**8.5**	CB	Sedge, cotton grass, -sphagnum, with or without a pine or birch layer;
Very moist reeds	negligible	3.5	**3.5**	CB, DRV, US	Sedge or reeds dominated wet habitats with or without birch, pine, alder or willow
Moderately moist forb meadows	20	negligible	**20**	CB, DRV	Grass dominated meadows with or without alder or spruce cover
Moist forb meadows	12.5	negligible	**12.5**	CB, DRV	Alder or willow scrub on fens

Table 9. Greenhouse gas emissions site type (GEST) emissions factors taken from Couwenberg et al. (2011), used in the estimation of GWP_{100} of peatlands and forested peatlands at the three sites studied. DRV= Desna River Valley; CB = Chyrvony Bor; US = Usoditsa.

Results and Discussion

The results for all three sites indicate that currently, they are stores of large quantities of carbon, which continue to grow. Chyrvony Bor, currently under productive forestry management, would benefit from increased nature protection and cessation of forestry (Table 10). The carbon stocks in trees will build over the next few decades, as trees continue to grow, and the forestry rotation ceases. This will result in an increase in area covered by mature trees, with greater carbon stores. However, as trees grow, their rate of sequestration decreases, until mature forests which sequester relatively little, compared to younger strongly growing trees. So, in the short term, the benefits of conservation management for total sequestration are clear, but once forest succession reaches equilibrium, sequestration will reduce. This must be balanced with the carbon stock losses related to continued forestry. Although forestry will result in an on average younger tree stock in harvested and replanted areas, with their higher annual sequestration capacity, we must also consider the stock lost through harvest. If this timber is used for 'conservative' practices such as building, then the carbon remains sequestered, and there is little net loss. However, if the wood is used as fuel, the stock loss is equivalent to the harvested stock, and there is a net loss of stock to the forest, and most sequestered CO_2 returns to the atmosphere.

At the Desna River Valley, the situation regarding forest carbon stock remains little changed regardless of the projected use changes (Table 11). Since these are largely concerned with grassland usage for grazing, most forest management (where the bulk of carbon resides) remains unchanged so stocks remain. The main change here is the maintenance or not of grazing areas for cattle, and the stocking density thereof.

The carbon stocks of Usoditsa reside in both the soil of the peatlands and the trees. Whilst in all scenarios trees remain to a large extent, the exploitation scenario leads to a loss of peat through extraction. The annual emissions due to this extraction will vary depending on the end use of that peat, either as fuel (all lost rapidly) or as soil conditioner (lost annually through soil oxidation at around 5% per year (Cleary et al., 2006), but the stock at the site will be lost rapidly through its removal, as will the slow sequestration of the bog moss ecosystem.

In their current states all three sites are sequestering large amounts of CO_2 from the atmosphere by virtue of tree growth. In two cases (Desna River Valley (Table 11) and Chyrvony Bor (Table 10)), this means the sites are climate cooling, sequestering more CO_2 from the atmosphere than they emit in GHGs to the atmosphere (GWP_{100}). However, Usoditsa is a small net emitter, due to its large area of intact peatlands (Table 12). Under increased nature conservation protection, the same pattern is evident, with Desna River Valley and Chyrvony Bor increasing their sequestration potential, due to increased tree growth and coverage, whereas Usoditsa increases its warming potential slightly, as mature forests sequester less CO_2 than young, rapidly growing trees. At Desna River Valley, even increased exploitation only leads to a modest decrease in sequestration, balanced by an increase in methane emissions from stock. However, these projected increases in human land-use are relatively small scale, and leave the majority of forest in tact. A much larger influence of human activity can be seen at Usoditsa, where, if peat extraction were to occur, we would see a transformation of a large CO_2 sequestering, small scale emitter of methane, into a large scale warming site through CO_2 loss to the atmosphere. Industrial scale peat extraction would increase the site's emissions by around 25 times over 100 years, though this would reduce over longer timescales as new vegetation establishes on worked-out peat areas.

We can see from all three sites that currently, they are subject to some human disturbance, but this is likely to be less than in the recent past, as political situations and local populations have changed, and there is some natural regeneration of vegetation after release of agriculture or industrial pressure. The direct influence of increased protection is small, in that sites are under little pressure in their current use. But, the extra protection offered to these sites will prevent the increase of human pressure likely if sites do not have further conservation management. Whilst in some areas (like the Desna River Valley) remoteness and current populations mean increased exploitation is likely to be low and have little influence on carbon stocks or ecosystems, at others this is more likely and the consequences much more profound for both ecosystems and carbon stocks, e.g. Usoditsa. In short, the greater the potential resource, the greater the danger of large scale global warming potential.

	Scenario	
	1. Continued Forestry	**2. Increased Protection**
GWP_{100} $tCO_{2\,eq}/y$		
CO_2 sequestered by trees	-105,054	-136,962
GWP_{100} of organic soils	61,334	61,334
Total	**-43,720**	**-75,628**
Storage tCO_2		
AGB	701,362	5,401,501
Litter	3,054,146	5,590,105
BGB	172,929	1,566,435
Total	**3,928,438**	**12,558,041**

Table 10. Total Global warming potential (GWP_{100}) and carbon stocks at Chyrvony Bor under current and alternative projected land-use.

	Scenario		
	1. Current	2. Increased Protection	3. Increased Exploitation
GWP_{100} $tCO_{2\,eq}$/y			
CO_2 sequestered by trees	-48,723	-105,739	-48,723
GWP_{100} of organic soils	7,012	13,753	6,173
GWP_{100} of animals	2,923	2,925	11,971
Total	**-38,788**	**-89,061**	**-30,579**
Storage tCO_2			
Vegetation	642,916	926,784	631,082
Soil	2,336,737	2,141,673	2,257,523
Total	**2,979,653**	**3,068,457**	**2,888,605**

Table 11. Total Global warming potential (GWP_{100}) and carbon stocks at the Desna River Valley under current and alternative projected land-uses.

	Scenario		
	1. Current	2. Increased Protection	3. Peat Extraction
GWP_{100} $tCO_{2\,eq}$/y			
CO_2 sequestered by trees	-44,086	-40,488.0	-36,047.1
GWP_{100} of organic soils	49,289	49,288.8	243,454.2
Total	**5,203**	**8,801**	**207,407**
Storage tCO_2			
AGB&BGB	3,944,262	5,266,841	2,675,799
Litter	20,628,630	20,610,057	30,941
Peat Soil	**4,370,782.2**	**4,370,782.2**	**0.0**
Total			

Table 12. Total Global warming potential (GWP_{100}) and carbon stocks at Usoditsa under current and alternative projected land-uses

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