Scoping for a Reserve Peatlands Protocol

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Executive Summary

It appears there is significant abatement potential for peatlands projects nationwide, with some 67 million metric tons of CO_2e currently being emitted by degraded peatlands in the U.S. annually.

There are a variety of methods and tools currently being used around the world to affordably and accurately model GHG fluxes from peatlands. The availability of tools currently applicable to U.S. conditions is less clear, however it appears that there would be sufficient tools and data available to make a peat protocol worthwhile, with further research to expand applicability in future. It appears that a protocol in this area could complement concurrent forestry activities and adopt aspects of the existing Reserve Forest Project Protocol, in a modular fashion, to account for such activities. Some aspects of forestry/peat interaction may need further consideration.

In terms of additionality, it appears that it will be possible to develop performance standards that target avoided conversion of all types of peatlands in certain areas, as well as the conversion of specific types of peatlands in other areas. It may also be possible to develop targeted standards that focus on restoration of already degraded peatland, of certain types, in certain areas. The following general observations could serve as useful hypotheses to direct the development of suitable performance standard additionality tests (PSTs):

> *Regional wetlands losses are concentrated in areas where peatlands are prevalent – making an objective conversion PST standard, for those areas, potentially feasible.*
>
> *Current wetlands reestablishment/new creation is concentrated (59%) on agricultural land – making a simplified PST standard excluding agriculture potentially feasible. However, most peat restoration opportunities will be on agricultural lands – making a differentiated PST or alternative method to include such activities desirable.*
>
> *Current wetlands reestablishment/new creation may not have the ecological integrity necessary to promote peatland GHG benefits – making a PST that prevents conversion of peatlands into other types of wetlands potentially feasible.*
>
> *Further analyses may demonstrate certain types of peatlands are at greater threat, in certain areas, to certain activities – making further targeted PST standards potentially feasible.*

Based on these and further factors, it would appear that the development of a Reserve protocol for peatland restoration would be feasible and provide significant GHG and wider co-benefits.

1 What are Peatlands?

Peatlands are a subset of wetlands, with soils of particularly high organic content. Peats are generally considered to be partly decomposed biomass with very high Soil Organic Compound levels, typically above 30%. It is worth noting that there are inconsistencies in definitions / typologies for wetlands and peatlands, which may cause issues regarding understanding conversion rates, etc. For example, the wetlands classification system used by National Wetlands Inventory program of U.S. Fish and Wildlife Service (FWS) does not distinguish between deep organic soils (peat) and wetlands with mineral soils.[1] Soils that contain mostly peat are known as histosols. An understanding of the makeup of peat and the process by which these materials accumulate is helpful for understanding changing carbon balances in peatlands.

For peat to form it is essential that the production of biomass is greater than its chemical breakdown.[2] Peat is generally assumed to be formed in wetland areas where flooding obstructs flows of oxygen (creating anaerobic conditions) and reduces the decomposition of vegetation, resulting in the fossilization of litter and soil.[3] These anaerobic conditions are created by a variety of specific hydro-topographic conditions such as marshes, swamps, bogs or mires.[4] Properties of such hydro-topographic units depend on many environmental factors, including climate, landform, local geology and hydrology.[5]

Carbon Flows through Peatlands – A Complex Picture

Peatlands act as both a sink and a source of emissions, depending upon the particular type of land and the timeframe taken.

Natural peatlands = CO_2 *sequestration +* CH_4 *emissions = NET sink*
Drained peatlands = CO_2 *emissions + possible* N_2O *increases = NET source*

Water levels are the single biggest factor affecting the ability of peatlands to serve as a GHG source or sink. When in a natural wetted state, CO_2 is sequestered by peatlands in great volumes through photosynthesis. At the same time, CH_4 is emitted due to the creation and maintenance of anaerobic conditions. Draining peatlands promotes aerobic metabolism and the rapid production of CO_2 (as the peat becomes oxidized), a decrease in CH_4 (as the anaerobic conditions become aerobic) and could also stimulate the further production of N_2O. Thus the natural decomposition, which is always occurring in peatlands, is actually sped up when the water is drained and anaerobic conditions are removed. Carbon loss is also further exacerbated by the increased likelihood of fire outbreak on drained peatlands, with the drained peat acting as a fuel sources for underground fires (peat is actually extracted and burned as a primary fuel source in several countries). Going back the other way, rewetting of peatlands again slows down the decomposition to a point where peat is actually further accumulating faster than it is being decomposed. Anaerobic CH_4 production becomes more prevalent, but the sequestration of large volumes of CO_2 into the peat itself is also spurred again, creating an overall NET sink of GHG emissions.

For our purposes, this complex carbon balance deserves greater scrutiny.

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[1] *The First State of the Carbon Cycle Report (SOCCR)*, Appendix F: Wetlands – Supplemental Material, pg.177.
[2] See: http://www.fao.org/docrep/x5872e/x5872e05.htm.
[3] Ibid.
[4] Ibid.
[5] Ibid.

The Carbon Balance in U.S. Peatlands

DRAINED PEATLANDS + AGRICULTURE = source
DRAINED PEATLANDS + FORESTRY = sink (in some cases)

Taking peatlands in the northern hemisphere as an example, consensus seems to be that historically these peatlands have been an important sink for GHG emissions over a 100-year timeframe, as organic matter has formed at a more rapid rate than it was destroyed (more CO_2 has been sequestered than CH_4 and N_2O has been released on a CO_2e basis).[6] The picture today is much more complicated.

Today, much of the peatlands in the U.S. have been deliberately converted to other land uses, through active drainage and land use change (see further details below), which include changes to forestland, cropland or development for housing, etc. In other areas, conditions in peatlands may have been altered, due to conditions like lowering of the water table and increased temperatures, without necessarily having undergone specific land use change. The carbon balance in these peatlands would seem to depend upon the current use that is being made of the land. To summarize, it would appear that drainage of peatlands for forestry may in fact maintain or enhance its effect as a carbon sink, whereas drainage of peatlands for conversion to agriculture will likely result in a net GHG emissions source and the drainage of peatlands, without the introduction of any new land use, may also result in the peatlands becoming a net GHG emissions source.

Some studies suggest that peatlands that have been drained and have subsequently been used to support forest growth may in fact be acting as carbon sinks.[7] It is worth clarifying that there are several types of peatlands which appear to support tree growth in their natural wetted state. Indeed, several VCS peat methodologies, to be discussed in more detail below, allow for and encourage concurrent activities with rewetting, including forestry. 'Drainage for forestry', on the other hand, appears to be the deliberate drainage of peatland areas to support the growth of non-indigenous tree species. In some systems in which peatlands have been drained to support forestry growth, the carbon fluxes are more complex: biomass primary production (i.e. trees and shrubs) increases, litter production increases, litter may be more resistant to decomposition and some decomposed litter may be stored in the peat profile, CH_4 emissions are decreased, with a net effect that may keep the carbon accumulation rate into the soil at the level prior to drainage or even higher.[8]

Conversion of peatlands into agricultural land, by contrast, seems relatively clearly to cause an increase in GHG emissions.[9] Studies in Europe and North America show that agricultural crop production on drained peatlands cause carbon losses as high as 37 to 73 tCO_2e/ha/yr, because of large fluxes in CO_2 and N_2O emissions, over decreases in CH_4.[10] In addition to these effects, agricultural management fundamentally alters the processes of wetlands and gradually leads to decreases in the wetlands area.[11]

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6 IPCC Expert Meeting Report, 2009, pg 14. http://www.ipcc-nggip.iges.or.jp/meeting/pdffiles/0905_MLP_Report.pdf.
7 IPCC Third Assessment Report - Working Group II: Impacts, Adaptation and Vulnerability, 5.8.3.2 Carbon Sink, 2001. http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=274.
8 Ibid.
9 Ibid.
10 Ibid.
11 Ibid.

Permanence / Reversals

As indicated by the preceding two sections, peatlands are susceptible to a range of reversal risks, both natural and anthropogenic. Solutions to the issue of permanence may need to be differentiated based on the geographical region and type of peatland. The section below will introduce some concepts which may be useful in understanding and addressing the issue of reversals and permanence.

As a first step in understanding reversals in the context of peat, it might be worth distinguishing between natural disturbances and those that are anthropogenic. In terms of natural disturbances, there are several key types of threats facing peatlands across the U.S., including the impacts of coastal storms and relative sea rises, and fires. Other changes in climatic conditions, most notably drought, may also be contributing to increased pressure on peatlands. Natural changes in vegetative communities may also be an issue that needs further investigation, as well as water and wind erosion. Typically these threats seem to be combined with several forms of anthropogenic pressures, resulting in complex interactions. Causes of peatland destruction which may be more readily attributable to specific anthropogenic actions include fire and deliberate hydrological drainage and associated land use change such as urban/rural development and conversion to agriculture/silviculture.

Work done by Duke University and FWS indicates that the presence of certain vegetative species may act as a natural buffer to reduced water levels which may be attributable to climatic changes – i.e. making peat more resilient to drought conditions.[12] It may be that the Reserve can work a 'regeneration' requirement into projects, which encourages/mandates the establishment of the types of vegetation which promote resilience of peat against drought or natural more minor disturbances to water availability. In terms of fire, work done by the FWS indicates that both the incidence of fires affecting peatlands and the magnitude of the damage done to peat are significantly elevated due to drainage of the peat.[13] Aside from hydrological requirements, project activities could include other fire management actions to mitigate against heightened fire risk, for instance mandated forest management activities for areas of forested peatlands. In terms of hydrology, a protocol could mandate the implementation and maintenance of certain infrastructure necessary to promote and maintain hydrological conditions conducive to natural peat states.

Co-Benefits from Peatlands Protection or Restoration

In addition to GHG emissions benefits, the protection of peatlands can bring a variety of benefits including water quality, soil health, fisheries and fauna benefits, and fire management benefits. Examples of such benefits include:

- Water quality improvements – peatlands are natural filters for catchment areas – their drainage enhances carbon and nitrogen run-off to sensitive waters; their protection sequesters these nutrients in-place
- Aquatic habitat – peatlands are very important nursery habitat for fish, especially migratory fish that return to rivers to spawn
- Terrestrial habitat – certain species which rely on peatlands are under threat – critically endangered – e.g. Pond pine canebrake
- Fire management - Improved hydrology aids in fire management / prevention

[12] Personal conversations with staff from Duke University and FWS, December 2012.
[13] U.S. FWS (2012).

    - Drained peatlands present danger of significantly more frequent fires (3 year intervals as opposed to 7 to 300 years in some areas) and more intensive burning – with fires actually burning intensely underground in the peat itself – resulting in massive soil loss up to 6ft in some areas[14]
    - Re-wetting permits above ground fire management with greatly reduced risk
  - Shrinkage/oxidation of peat may lead to loss of entire peat profile and exposure of underlying nutrient-poor substrates or potential acid sulfate soils – which when exposed to air/water can react and form sulfuric acid - which in turn can release various heavy metals – which can create a variety of adverse impacts including killing vegetation, acidifying groundwater, killing aquatic life, etc.

The U.S. FWS presentation to CAR/FWS also stated avoided wildfire response costs for peatland protection in NC projects as follows[15]:

WILDFIRE	REFUGE	COST
Evans Road	PLNWR	Nearly $20M
South One	GDSNWR	$12.5M
Lateral West	GDSNWR	$12M
Pains Bay	ARNWR	>$14M; up to $350K/day

~ $58.5M total

[14] U.S. FWS (2012).
[15] Ibid.

2 Additionality and Feasibility of Projects

Several regulatory mandates and disincentives exist to encourage the protection of peatlands. Current destruction rates for peatlands in the U.S. appear to be very low, indicating that it might be difficult to demonstrate the additionality of projects based on their protection as wetlands. On the other hand, restoration of peatlands does not appear to be as common, is not mandated, and does not have successful incentives in place. Based on the assessment of U.S. FWS pilot peatland protection projects, it would appear that such restoration projects could be funded by carbon revenues from associated emissions reductions. These issues will be discussed in more detail below.

Historical and Current Peatlands in the U.S.

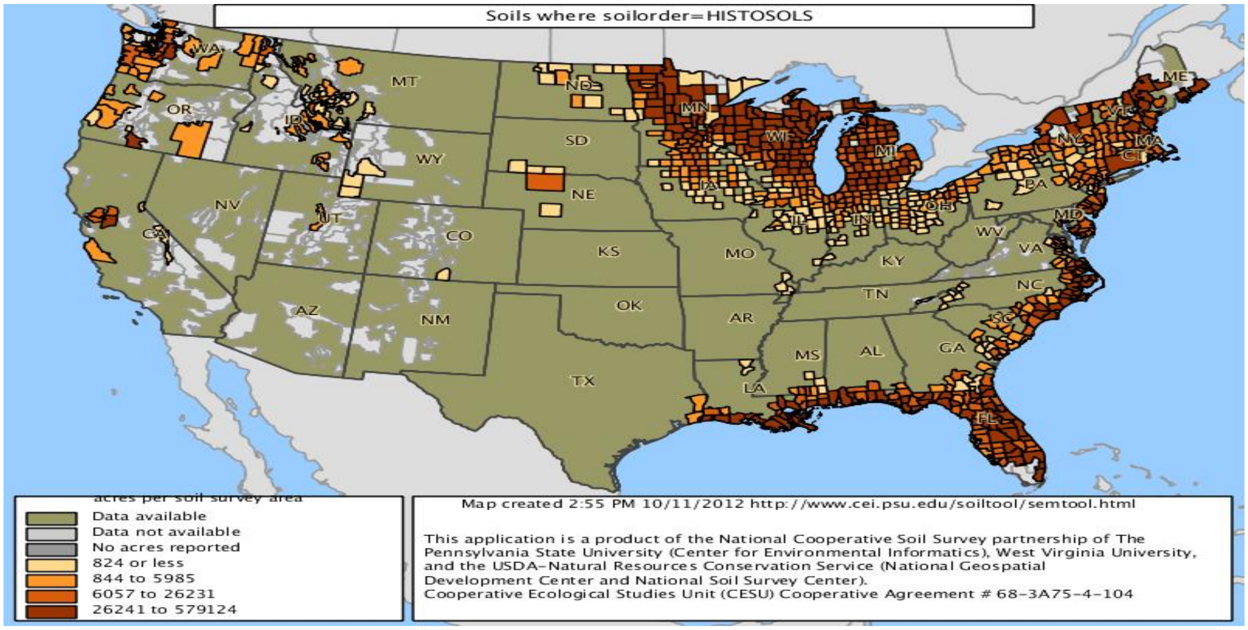
> *Around 0.1% (60,000 acres or 243 km^2) of U.S. peatlands are currently being lost each year. Degraded peatlands in the U.S. emit some 67 MtCO_2e annually.*

Differences in how peatlands are classified make it somewhat difficult to find consistent data on current levels of peatlands and rates of destruction over time. Despite this, consensus seems to be that much of the peatlands found in the U.S. have been drained to make way for alternative land uses including logging and agriculture, and to enable peat extraction.[16]

According to the EPA,[17] more than 220 million acres (890,308 km^2) of wetlands are thought to have existed in the 1600s. Since then, extensive losses have occurred, with the mid-1950s to 1970s exhibiting major rates of national wetland loss, which have since slowed.[18] According to researchers at North Carolina State University (NCSU), by some estimates, 22 states have lost at least 50% of their wetlands; Indiana, Illinois, Missouri, Kentucky and Ohio have lost more than 80%; and California and Iowa have lost nearly 99%.[19]

The EPA states that drainage of wetlands for conversion to agriculture has been significant in the past, however is currently declining, and that development pressure is emerging as the largest cause of wetlands loss.[20] According to Wetlands International and the U.S. Climate Science Program, currently there are approximately 224,500 km^2 of peatlands in the U.S. (including Alaska and the 48 lower states).[21] The U.S. Soil Survey map below shows current peatland distribution in the 48 contiguous U.S. states.

[16] According to USGS statistics the U.S. has extracted on average over 640,000 t of peat annually since 1960. See USGS *Peat Statistics*, U.S. Geological Survey 2011.
[17] EPA, *Threats to Wetlands: What is the Status of Our Nation's Wetlands*, 2001. http://www.epa.gov/owow/wetlands/pdf/threats.pdf.
[18] See http://www.epa.gov/owow/wetlands/pdf/threats.pdf.
[19] See http://www.water.ncsu.edu/watershedss/info/wetlands/wetloss.html.
[20] Ibid.
[21] Ibid, and Wetlands International *The Global Peatland CO_2 Picture: Peatland status and emissions in all countries of the world* (draft), 2009.



Sourced from: http://apps.cei.psu.edu/soiltool/.

The following table, using statistics from Wetlands International, sets out statistics for peatlands, areas under degradation and associated emissions.

	U.S. - Alaska	U.S. - Lower 48 States	U.S. TOTAL	Canada	Mexico
1990 Total area of peatlands (km^2)	132,000	93,000	225,000	1,134,000	10,000
2008 Total area of peatlands (km^2)	132,000	92,000	224,000	1,133,836	9,910
Total area of peatlands - % change from 1990 to 2008		1.0752688	0.4444444	0.0144621	0.9
1990 Total area degrading peatlands (km^2)	109	13,120	13,229	1,820	1,000
2008 Total degrading peatlands (km^2)	110	13,130	13,240	1,820	1,000
Total area of degraded peatlands - % change from 1990 to 2008	0.9090909	0.0761615	0.0830816	0	0
Total emissions in 2008 from degrading Peatlands ($MtCO_2e$)	0.2	67	67.2	4.6	3.5
Total technical possible future emissions from peatlands in 2008 ($MtCO_2e$)	51,053	45,024	96077	510,477	4884

Data sourced from Wetlands International (2009).

According to the U.S. Climate Change Science Program's State of Carbon Cycle Report, annual emissions from *wetlands* that have been converted into other uses are approximately 67 $MtCO_2e$.[22]

The EPA states that approximately 243 km^2 or 60,000 acres of peatlands are currently being lost each year.[23] Based on the statistics tabled above, this would represent an annual decline of 0.1% of national peatland area. Material from NCSU states that some researchers believe that a significant percentage of the nation's remaining wetlands have been substantially compromised hydrologically, but this has not been measured.[24]

Developing Performance Standards for Peatland Projects

> *Regional wetlands losses are concentrated in areas where peatlands are prevalent – making an objective conversion PST standard, for those areas, potentially feasible.*
>
> *Current wetlands reestablishment/new creation is concentrated (59%) on agricultural land – making a simplified PST standard excluding agriculture potentially feasible. However, most peat restoration opportunities will be on agricultural lands – making a differentiated PST or alternative method to include such activities desirable.*
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> *Further analyses may demonstrate certain types of wetlands are at greater threat, in certain areas, to certain activities – making further targeted PST standards potentially feasible.*

An important question for this scoping exercise is whether the project type easily lends itself to a standardized, performance based approach to determining additionality and estimating baselines. In developing new protocols, the Reserve generally tries to set program-wide standards of performance applicable to all projects of the same type – i.e. a standard of performance applicable to all peatlands projects, to be established on an *ex-ante* basis. The performance threshold represents "better than business-as-usual" management of peatlands. If the project meets the threshold, then it exceeds what would happen under the business-as-usual scenario and generates surplus/additional GHG reductions. Performance standard tests (PSTs) can be developed to discriminate between projects on an activity basis, geographical basis or by the types of technology employed, in addition to any relevant performance based metrics (i.e. best practice standards). This section of the paper will now look at issues relevant to the development of PSTs for a peatlands protocol.

One valuable source of data on wetlands (and hence peatlands) trends in the U.S. is the FWS *Status and Trends of Wetlands in the Conterminous U.S.*[25] It is important to realize that this data can provide a valuable insight into the possible peatlands trends, however it will be necessary to look more specifically at trends in peatlands before finalizing any PSTs. The Reserve is currently working with colleagues at the U.S. FWS to source targeted data on U.S. peat trends.

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[22] *The First State of the Carbon Cycle Report (SOCCR)*, Appendix F: Wetlands – Supplemental Material, Table F.2, pg 180.
[23] EPA (2001).
[24] See http://www.water.ncsu.edu/watershedss/info/wetlands/wetloss.html.
[25] The Reserve is continuing to explore sources for further data more specifically relevant to peatlands in the U.S.

All of the details in the section are taken from the FWS *Status and Trends of Wetlands in the Conterminous United States 2004 to 2009* report.[26] Generally speaking, the data presents evidence of significant ongoing wetlands regeneration activities, as well as efforts to avoid conversion of wetlands, which may present some challenges to developing broad-brush PST standards. However, the latest FWS report does present insights into where more targeted PST standards may be useful.

In terms of the overall national state of wetlands, data over the last few decades indicates a marked reduction in the rates of wetland losses across the nation, with a reversal of this long-standing trend occurring over the last five-year study period. This latest study also demonstrates that some regional trends in wetland change can be contrary to national trends and perhaps most importantly, that areas of more extensive wetlands loss exist. Geospatial analyses of the 2004 to 2009 data demonstrates regional wetlands loss appears to be concentrated in areas where peat soils are prevalent, as depicted in Figure 49 below. Broadly speaking, this may present an opportunity for the Reserve to target activities in such areas. Further analysis also reveals that certain types of wetlands may be at greater threat, in certain areas, to certain activities. This type of further analyses may prove effective in developing PST sub-standards further targeted accordingly.

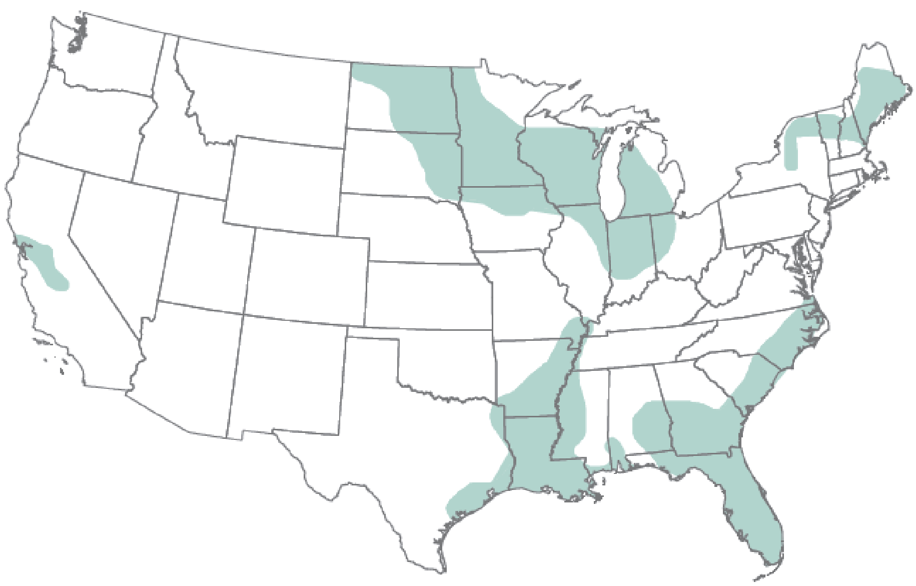

Figure 49. This study found particular regions of the conterminous United States experienced different rates of wetland loss depending on many factors. The regions illustrated on the map experienced the highest rate of freshwater wetland loss to upland between 2004 and 2009. (This examination was based on geospatial analysis of data from this study. There may be no statistical relevance attached to any region(s) depicted.) NOTE: This information was intended to illustrate the observed incidence of higher wetland loss rates by generalized region. It should not minimize the importance of other wetland loss or gain actions that occurred elsewhere.

One further point of interest is that there appears to be a relative lack of qualitative data on newly emerging wetlands. Further analyses of such wetlands may potentially reveal that these are not suitable for the protection or enhancement of peatlands and associated GHG emission benefits.

[26] U.S. FWS, *Status and Trends of Wetlands in the Conterminous United States 2004 to 2009*. http://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Wetlands-in-the-Conterminous-United-States-2004-to-2009.pdf.

It appears that there are high rates of conversion of peatlands, particularly to agricultural uses. This type of peat loss appears to be hidden somewhat within the statistics on wetland emergence and reestablishment, particularly on agricultural land, which appear to be essentially the conversion of viable natural peatlands into other types of wetlands which may not support peat.

The Reserve Forest Project Protocol (FPP) includes a methodology for valuing alternative uses of land, as a means to determine the level of threat that conversion presents for that particular area of land. This type of assessment may be useful for assessing potential avoided conversion of peatlands.

The following couple of paragraphs will present some of the key findings of the 2004 to 2009 FWS report.

At the time the study originated, average annual wetlands loss rate was 458,000 acres. From the mid-1970s through to the mid-1980s, this loss rate had declined to 290,000 acres annually. In 1998, the wetland loss rate was about 59,000 acres annually, and in 2005 wetland area actually gained by an estimated 32,000 per year. Statistics from the latest FWS study, from 2004 to 2009, show that this long-standing trend in wetland loss reduction has reversed, and that during this period there was an annual decline in wetlands of some 12,500 acres.

The rate of wetland reestablishment or creation between 2004 to 2009 increased by 17% from the previous study period, yet the overall net gain in freshwater wetlands area (21,900 acres) was substantially lower than for the previous 1998 to 2004 period (220,000 acres). More than 59% of wetlands gains occurred on agricultural land between 1997 and 2007. However, certain parts of the country, such as the Midwest, demonstrated increased drainage of wetlands, acreage enrolled in conservation programs declined in certain areas (for instance, North Dakota experienced a 12% decline in enrollment in the NRCS Conservation Reserve Program).

Overall it appears that there has been substantial reclassification of wetlands, from wetlands classified as freshwater forested and vegetated to the freshwater emergent category, with a notable increase in ponds (agricultural, industrial and urban, with simultaneous decreases in natural and aquaculture ponds). This has been coupled with a lack of qualitative data on the ecological integrity of such newly formed (or newly classified) wetlands and their ability to support the continued existence of peatlands, or at least the continued carbon balance in such lands. While care should be taken not to undervalue the reestablishment efforts observed to date, there may nonetheless be value in dissecting this data further, to determine whether a PST targeted at the avoided conversion of peatlands into wetlands that do not support continued GHG benefits of the peatlands, may be feasible.

Over the 2004 to 2009 period, 489,000 acres of former upland were re-classified as wetland, attributed to wetland reestablishment and creation on agricultural lands and other uplands with undetermined land uses. The rate of wetland reestablishment increased by an estimated 17% from the previous 1998 to 2004 study period. During the latest 2004 to 2009 study period, some 421,000 acres of forested wetland were changed to emergent wetlands, where the forests were cleared, but the hydrology remained. There was some loss of freshwater marshes to rural/urban development (17,000 acres) and silviculture (29,000 acres).

Freshwater wetland losses, primarily attributed to urban and rural development and silviculture operations, continued in regions of the country where there has been potential for wetlands to come into conflict with competing land and resource development interests. Urban and rural development combined accounted for 23% of wetland losses, estimated at some 129,000 acres, an 8% declining change since the 1998 to 2004 period. Wetlands losses in silviculture increased considerably since 2004, accounting for some 56% of all wetlands losses from 2004 to 2009. Declines in forested wetlands were significant, some 633,000 acres, and were the largest losses sustained since the 1974 to 1985 time period, attributable 38% to silviculture, 26% development, 19% upland other land use and 13% to agriculture. Urban and rural development accounted for some 26% of this change (some 100,000 acres), representing irreversible losses, as wetlands have been filled, drained or otherwise developed for buildings or other support infrastructure. An estimated 150,000 acres of forested wetlands were lost to silviculture primarily in the Southeastern U.S., corresponding to 20- to 25-year rotation cuts. Although the tree loss itself did not amount to wetlands loss, associated activities, such as intensive site prep, altered or eliminated site hydrology. It has been estimated that single species pine forests cover some 55 million acres in Southeastern states and are subject to management actions deleterious to wetlands. Wetland areas that were replanted as part of management silviculture operation could not be distinguished from wetland restoration activities, effectively masking reestablishment estimates.

Some 180,000 acres of emergent wetlands became shrub wetland, corresponding largely to managed forest harvest rotations in active silviculture management. There was relatively little natural succession of shrub wetlands leading to mature forests, as plantations matured to become economically mature before reaching ecological maturity. An estimated 142,000 acres of freshwater shrub wetland were lost to become upland silviculture between 2004 and 2009.

The following figures are drawn from the latest FWS report and are illustrative of the above changes:

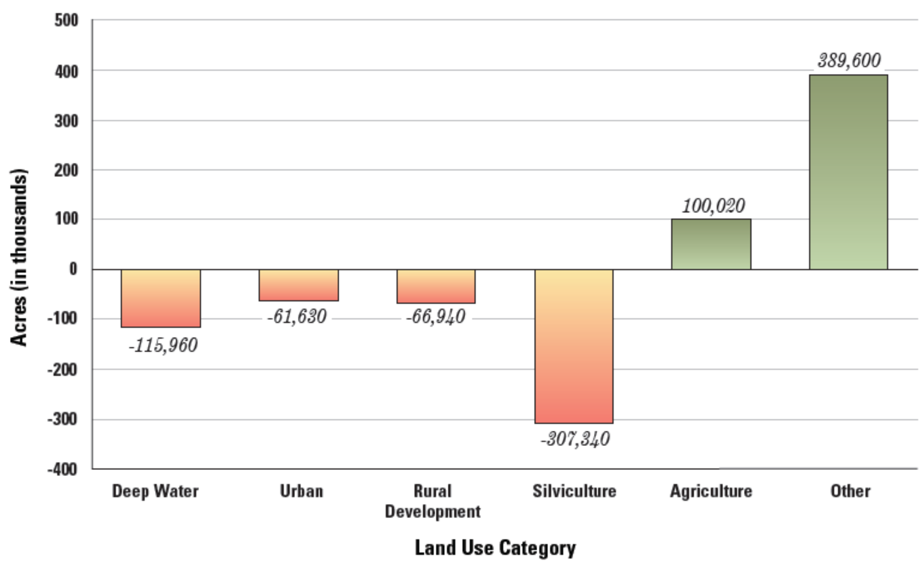

Figure 22. Estimated net gains and losses of wetland acres (saltwater and freshwater) attributed to the various upland land use categories and deepwater, 2004 to 2009.

Table 4. Status and changes in freshwater wetland types between 2004 to 2009. The coefficient of variation (CV) for each entry (expressed as a percentage) is given in parentheses.

Wetland Category	*Area, In Thousands of Acres*				*Area (as Percent of all Freshwater Wetlands, 2009*
	Estimated Area, 2004	*Estimated Area, 2009*	*Change, 2004–2009*	*Change, (In Percent)*	
Freshwater Emergent	27,162.7 (7.7)	27,430.5 (7.6)	267.8 (85.8)	1.0%	26.3%
Freshwater Shrub	18,331.4 (4.2)	18,511.5 (4.2)	180.1 (*)	1.0%	17.8%
Freshwater Forested	52,256.5 (2.7	51,623.3 (2.7)	-633.1 (30.7)	-1.2%	49.5%
Freshwater Vegetated Wetlands	97,750.6 (2.9)	97,565.3 (2.9)	-185.3 (*)	-0.2%	93.6%
Aquaculture Ponds	380.7 (27.6)	266.2 (33.4)	-114.6 (32.4)	-30.1%	0.3%
Agriculture Ponds	2,828.5 (4.1)	2,980.8 (3.9)	152.4 (25.3)	5.4%	2.9%
Industrial Ponds	373.4 (17.5)	410.5 (16.4)	37.1 (29.7)	9.9%	0.4%
Natural Ponds	2,103.5 (11.3)	2,088.8 (11.4)	-14.7 (*)	-0.7%	2.0%
Urban Ponds	816.1 (6.3)	963.0 (6.2)	147.0 (12.9)	18.0%	0.9%
Freshwater Ponds	6,502.1 (4.6)	6,709.3 (4.5)	207.2 (29.6)	3.2%	6.4%
All Freshwater Wetlands	104,252.7 (2.8)	104,274.6 (2.8)	21.9 (*)	0.0%	–

** Statistically unreliable.*

Percent coefficient of variation was expressed as (standard deviation/mean) × 100.

There are several existing VCS GHG project protocols dealing with peatlands, which will be discussed in more detail later. While all of these adopt project by project assessments of additionality based on a standard VCS additionality tool, one of these protocols utilizes a relatively standardized approach to assess additionality. The VCS *Rewetting of Drained Tropical Peatlands in Southeast Asia* methodology uses standardized applicability criteria for determining appropriate baseline scenarios, whereby demonstration of having met the criteria equates to demonstration that an appropriate baseline scenario has been employed. The methodology also includes a statement to the effect that, unless regulations are present to mandate peatland restoration, project activities (meeting the protocol criteria) would typically be considered additional. The combination of standardized baseline scenario applicability, with a tacit assumption of additionality if applicability conditions are met, is akin to a practice-based performance standard.

Given that technologies and practices necessary for peatlands rewetting are commonly available and long proven (i.e. the utilization of dams/dykes, etc.), the development of appropriate applicability conditions to underpin a practice-based performance standard could be relatively simple.

Current Regulations and Additionality

Complex, relatively effective regulations exist to prevent destruction of wetlands. Regulations do not mandate restoration – rewetting of peatlands.

A notable feature of U.S. wetland protection policy today is that there is no specific, comprehensive national wetland law. Rather, regulations protecting wetlands have evolved over years in a piecemeal fashion, spread across multiple agencies, often utilizing laws originally intended for other purposes.[27]

Despite this, current rates of peatland loss, particularly relative to suspected historical rates of loss, demonstrate the relative success of these measures in preventing further loss of peatlands. While these regulations present drivers for the protection of wetlands, there do not appear to be any existing or pending regulations that mandate the restoration of already degraded peatlands. Thus focusing on peatland restoration projects would be one way to make it relatively easy to distinguish between voluntary activities and those that may be required by law.

At the heart of wetlands protection in the U.S. is Section 404 of the Clean Water Act (S404). S404, enforced jointly by the EPA and the U.S. Army Corps of Engineers, regulates the discharge of material into U.S. waters. S404 serves as the linchpin for ecosystem markets in the U.S. by establishing a system whereby effectively whenever a person intends to interfere with a waterway or wetland, they must: consider all alternatives, satisfy certain criteria, look at mitigation and compensation means, and ultimately ensure NO NET LOSS (of wetlands) occurs.[28] Individual permits are not required in every case, but rather categories of permits are created on a regional/state/national level, with individual permits only required for more significant potential wetland impacts. The regime creates a sequential review process whereby the applicant must show that first all available alternatives have been considered and that no practicable alternative exists which would have less impact. Furthermore, no discharge is permitted if it can cause significant degradation. Once these criteria are satisfied, the proponent must look at compensation/mitigation, with the end result being NO NET LOSS (of wetlands).

According to some commentators, a number of problems exist with these protection efforts, including inconsistent application, and inadequate monitoring and enforcement.[29] One notable gap in the coverage of this regulation is the exemption for most agricultural activity, a significant source of land use change and thus wetland alteration and loss. In North Carolina for instance, many of the peatlands were converted for agriculture and have been deemed ‘prior converted croplands’, and therefore, despite retaining their peat soils, these lands do not receive Clean Water Act protection.[30]

On the state and local level, there are also multiple regulations in place which provide for wetlands protection, but do not mandate any restoration.[31] It may be possible to identify classes of peatlands protection project activities that may pass a Legal Requirement Test, however this would likely require substantial further and periodical analysis. The class of peatlands described

[27] See http://www.water.ncsu.edu/watershedss/info/wetlands/protect.html#stwet.
[28] See http://www.water.ncsu.edu/watershedss/info/wetlands/protect.html#stwet.
[29] Ibid.
[30] Based on discussions with U.S. FWS staff, January 2013.
[31] See EPA summaries and analysis of State wetlands protection programs here: http://water.epa.gov/type/wetlands/initiative_index.cfm.

above, ‘prior converted’ croplands in North Carolina, may pass a legal requirement test aimed at avoided conversion activities.

There are a number of non-regulatory means employed on a federal level to protect wetlands, the most notable being the ‘swampbuster’ provisions of successive Farm Bills.[32] The ‘swampbuster’ provisions discourage the further conversion of wetlands for agricultural commodity production by withholding all USDA program benefits to any person farming on wetlands converted after 1985. These do not mandate anything, but rather add to the suite of policies that create the common practice protection of existing peatlands.

Ecosystem Service Stacking

> *NOTE: Some of the funding identified below might be available to assist with the development of a peatlands protocol.*

There are a number of positive incentives in place that provide funding to promote the restoration of wetlands. NRCS funding has been utilized by over 11,000 private land holders over the last 20 years to assist with the protection of wetlands, under NRCS Wetlands Reserve Program (WRP).[33] The program has been established under the Farm Bills, and so is most suited for frequently flooded agricultural lands. The NRCS WRP facilitates the establishment of temporary or permanent agreements (including registering easements) on land and pays up to 100% of restoration costs on those lands.[34]

The EPA administers Wetland Program Development Grants, which have funded several projects aimed at enhancing the protection and restoration of wetlands.[35] A preliminary scan through their database reveals that a very small number of these grants may be facilitating peatland restoration activities. The EPA’s Enhancing State and Tribal Wetlands Programs Initiative provides some technical and financial assistance to state and tribal governments to carry out wetlands works. While no specific details have been found regarding peatland protection or restoration activities funded under this initiative, some further research may be in order.

Despite the availability of these funds and non-regulatory support measures, it appears that unfavorable economics and the lack of enforceability of restoration-related policies have contributed to the limited overall impacts of such measures.

Project Level Abatement Potential and Associated Costs

> *10.8 tCO_2e/acre/year – with one-off establishment costs as low as \$140 to \$310 per acre.*

The abatement potential of taking degraded peatlands through to fully restored peatlands has been estimated across several project areas in North Carolina, at approximately 10.8 tCO_2e/acre/yr.[36] This figure is considered illustrative of GHG emissions abatement potential, however should not be taken as a constant rate to be expected over a 100-year period, as accretion/oxidation rates are influenced by many factors and are therefore expected to fluctuate

[32] See a summary by the FWS at: http://www.fws.gov/policy/504fw4.html.
[33] See http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands/.
[34] Ibid.
[35] See http://iaspub.epa.gov/pls/grts/f?p=101:3:1721250477803701::NO:RP.
[36] *Pocosin Lakes Cooperative Peatland Restoration Project – Benefits, Progress and Landscape Scale Opportunities*, U.S. FWS, 2012.

over time. Further research to identify alternative carbon abatement estimates, over more diverse geographical locations, peat types and over longer time periods, may be useful. Costs to implement those rewetting efforts were estimated at between $140 to $310 per acre, as a one-time investment, depending on whether the work was contracted out or performed in-house.[37] It should be noted, however, that the ACR methodology sites a long summary of U.S. FWS, EPA and NRCS funded wetlands restoration projects with average costs of between $8,000 to $60,000 per acre.[38] A study undertaken by the U.S. Army Core of Engineers in 2009 indicates that such restoration efforts may have been focused too broadly and are thus too expensive, recommending that future projects target most urgent problems.[39] Discussions with FWS staff reveal that for the NC work giving rise to the cost estimates above, underlying hydrological studies were already in place and therefore not accounted for, potentially significantly reducing the apparent restoration costs.[40] These costs would presumably make such projects uneconomical without amortization over multiple years and significant outside funding beyond carbon revenues. It may be possible to get further figures from parties who have undertaken EPA WGD funded assessments of peatlands. The table below shows a simple breakdown of costs of abatement potential over a 100-year horizon, based on the FWS projects in NC.[41]

Table 4. Projected carbon benefits over 100 year period of peatland restoration project at Pocosin Lakes NWR

Project Year[a]	Carbon Sequestration Potential		Projected Cost for Remaining[b] Restoration Need	
	t CO_2-e/ac (metric)	t CO_2-e/ac (short tons)	$/ t CO_2-e (metric)	$/ t CO_2-e (short ton)
0	10.8	12	5.37	4.83
10	108	120	0.54	0.48
50	540	600	0.11	0.10
70	756	840	0.08	0.07
100	1080	1200	0.05	0.05

[a] Project duration of up to 500 years is possible in areas of the based on the depth of the peat lens
[b] For remaining 8,300 acre restoration need at Pocosin Lakes National Wildlife Refuge

[37] Ibid.
[38] See the list of these projects and summarized costs here: http://lacoast.gov/new/Projects/List.aspx.
[39] *Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report*, U.S. Army Corps of Engineers, 2009, pg. 292. New Orleans District, Mississippi Valley Division.
[40] Personal conversations with FWS staff, October 26, 2012.
[41] *Benefits of Wetland Hydrology Restoration in Historically Ditched and Drained Peatlands: Carbon Sequestration Implications of the Pocosin Lakes National Wildlife Refuge Cooperative Restoration Project*, pg. 18. http://www.fws.gov/raleigh/pdfs/PeatlandRestoration_CSeqBenefits_Jan2010.pdf

3 Developing a Peatlands Protocol

Peat restoration projects focus on three activities:

1. *Keeping peat wet*
2. *Increasing woody biomass*
3. *Managing fire*

As indicated previously, water levels are the single biggest determinant of GHG fluxes in peatlands. Activities to control peatland GHG emissions therefore primarily focus on ensuring peatlands are wet.

A typical peatland project may therefore have a baseline scenario of a drained project area, with the project activity involving the introduction of water to that area. The avoidance of further draining of existing peatlands is also focus of other methodologies. In this scenario the baseline would consist of a theoretical draining of peatlands, beyond current levels and the project scenario would consist of maintaining and/or increasing water levels on the project area. Existing protocols seem to focus on drainage that resulted from land use change from peatlands to agriculture/forestry/peat extraction. The Reserve could also consider baseline scenarios where the lowering of the water table is not necessarily attributable to particular anthropogenic actions.

Aside from modeling carbon fluxes in the peat itself (CO_2 release from the oxidation or breakdown of peat and increased CO_2 sequestration through the accumulation of further peat), there are two additional main sources of GHG fluxes that are typically attributed to peatland projects: changes in woody biomass and fire management.

Peatlands and Forestry

It appears that several types of peatlands can support multiple tree and vegetation species. Indeed, in relation to tropical peat swamps, it appears that tropic swamp natural forests are crucial, providing the plant material and facilitating the wet conditions for peat formation, carbon sequestration and carbon storage.[42] However, a study by the UK Forestry Commission shows that the value of peatlands as a carbon store can be lost if planted with trees, and that the successful use of forestry in regeneration activities is possible, but challenging.[43] The study concluded that, at least in the case of bogs, trees become a problem when sufficiently numerous and dense so as to eventually form closed canopy woodland, thus shading out the bog vegetation and drying the peat.[44]

It may be worthwhile for the Reserve to further research the types of vegetation that might be suitable across various peatland areas in the U.S. and perhaps allow for concurrent forestry activities with any peatlands projects, where it can be shown that the species used are not detrimental to the restoration activities or the maintenance/enhancement of carbon stores. It may also be beneficial to allow for harvesting/removal of trees for rewetting sites, where this is seen as beneficial or necessary for restoration of the peat. It is worth noting that work underway by the USDA and Duke University is investigating the possibility of undertaking peat restoration

[42] Couwenberg et al. (2010). *Greenhouse gas fluxes from tropical peatlands in Southeast Asia*. Global Change Biology **16**: 1715-1732.
[43] Anderson (2010). *Restoring afforested peat bogs: results of current research*.
[44] Ibid, pg. 7.

work on land under active agricultural/silvicultural land, with a view to demonstrate that significant benefits can be realized without compromising productivity.

Aside from the issue of ensuring the correct trees are grown on the correct soils, facilitating accounting for woody biomass (both above and below ground) could be as simple as adopting existing aspects of the Forestry Project Protocol in a modular fashion. All of the VCS peat methodologies mentioned in this paper allow for the accounting of tree carbon stocks, by way of adopting existing VCS forestry accounting methods. The FPP Version 3.3[45] also introduces a methodology to account for fluxes in project soil carbon stocks. This approach will be discussed in more detail in the section exploring existing protocols for peatlands.

Peatlands and Fire Management

Emissions from peat fires are negatively correlated with water level, when peat is drained, this presents a ready fuel source for fires. Work undertaken by the U.S. FWS indicates that, in some areas, the draining of peat can result in significant increases in fire frequency (every 3 years as opposed to 50+ years) and that fires in some areas resulted in the loss of up to 6 feet of peat soil and the release of millions of tonnes of CO_2e.[46]

Fire management has been included in conjunction with peat protection/restoration, in a number of existing GHG mitigation methodologies. The VCS *Baseline and Monitoring Methodology for the Rewetting of Drained Peatlands Used for Peat Extraction, Forestry or Agriculture Based on GESTS*, for instance, employs a simplified 'fire premium' to estimate and conservatively account for reduced emissions from fire management, without requiring complex baseline scenarios for fires. Under that procedure, the emission reductions from hydrological activity are estimated first. Next, the cumulative area burnt in a fire reference period is calculated. Provided the cumulative area in the reference period is at least 25% of the project area, statistical fire risk is established and fire management actions are implemented, up to 20% of reduced emissions associated with the hydrological activity can be added as a 'fire premium'.

The VCS *Baseline and Monitoring Methodology for Avoiding Planned Deforestation of Undrained Peat Swamp Forests* employs a procedure for quantifying emission reductions from fire prevention activities described in the IPCC *Good Practice Guidelines for Land Use, Land Use Change, and Forestry* (GPGLULUCF, 2003). This method uses literature values or site-specific measurements for estimating the peat subsidence from burning.

GHG Assessment Boundary

> *CO_2 the primary focus – CO_2 emissions reduced and potentially sequestered.*
> *CH_4 can likely be safely excluded in some cases, but N_2O can be conservatively excluded across all project types.*

A peatlands protocol should primarily focus on CO_2 emissions, but also include CH_4 emissions. The following table gives an indication of potential SSRs to be included in a peat protocol – it excludes N_2O, as according to consensus, this would be conservative.[47]

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[45] See http://www.climateactionreserve.org/how/protocols/forest/dev/version-3-3/.
[46] U.S. FWS (2012).
[47] Couwenberg et al. (2009). *Greenhouse Gas fluxes from tropical peatlands in Southeast Asia*, pg. 8.

SSR	Source	Gas	Explanation	Quantification Method	Used in Other Protocol
1) Peat Carbon Stocks	Oxidization of the peat after being drained - releases GHGs	CO_2	Breakdown of carbon material sped up once anaerobic conditions removed - Massive releases of CO_2 as peat oxidizes once soils drained;	Subsidence	VCS Baseline and Monitoring Methodology for Avoiding Planned Deforestation of Undrained Peat Swamp Forests
				Water level modeling	VCS Rewetting of Drained Tropical Peatlands in Southeast Asia
				Vegetation modeling - GIS mapping, e.g. LiDAR + GESTs approach	VCS GESTs
	Buildup of more peat sequesters GHGs		Once anaerobic conditions are reinstated, peat degradation slows down and eventually more peat can be generated - sequestering CO_2;	All three above	
	Organic soils continue to decay slowly under anaerobic conditions - releasing CH_4	CH_4	Rewetting reintroduces anaerobic conditions - resulting in transient CH_4 spikes;	Possibly DNDC	Possibly VCS GESTs in U.S.
2) Woody Biomass	Above / below ground - CO_2 sequestered in trees and shrubs – litter, etc.	CO_2	Sequestered	Modular approach using quantification from existing forestry protocol	All above
3) Fire Management	Activities to reduce incidence of fires	CO_2	Avoided CO_2 release due to reduced risk and incidence of fires burning in the peat itself - as result of peat rewetting - requires modeling of both peat and vegetation levels	All approaches CO_2 measuring alternatives above	VCS GESTs

As peat is drained, the carbon balance in the peat itself changes, CO_2 emissions increase on a large scale and CH_4 emissions reduce. Conversely, rewetting of peat stops the oxidation/release of CO_2, allows for the sequestration of CO_2 through the accumulation of further peat, and increases CH_4 due to the anaerobic conditions created. The picture with respect to N_2O emissions is complex; however consensus is that N_2O emissions from highly organic soils decrease due to rewetting.[48] N_2O emissions have thus been excluded from the VCS GEST methodology, as a conservative measure.

[48] Couwenberg et al. (2009). *Greenhouse Gas fluxes from tropical peatlands in Southeast Asia*, pg. 8.

Leakage

Several forms of leakage need consideration: market leakage and water loss. The first includes considerations of displacing baseline land use activities outside of project areas and the loss of resources that may come from a shift away from those activities.

In consideration of leakage, the ACR methodology states that "[w]etlands are distinct from other terrestrial sequestration types in that there is generally no activity shifting to other locations, such as with silviculture or agriculture, when wetlands are restored. Healthy wetlands increase the production of goods supplied to a market, such as fisheries, game hunting, or hurricane protection, without a corresponding reduction in the demand for that good."[49] That particular methodology does not allow for the harvesting of timber or fuel wood, and therefore does not consider leakage of such resources as a likely result of wetlands protection.

In relation to water loss, there is the possibility that project areas that are connected via hydrological systems with areas outside the project area could experience loss of their water. This not only reduces the benefits of rewetting, but the water itself can also carry significant amounts of dissolved organic matter, which will support GHG production in other areas. To avoid the effects that this may have on the peat itself and ultimately the net emissions reductions, the various protocols prefer that project areas be chosen that have distinct hydrological areas and are not connected with other wetlands areas. If hydrological connectivity cannot be avoided, then the project must account for the GHG leakage caused by water flows outside the project boundary. It should be noted, however, that a properly functioning rewetted peatland may export less particulate and dissolved carbon to hydrologically connected areas, compared to the baseline scenario of drained areas of peat.[50] This possibility should be explored further, and if applicable to given areas/systems, emissions leakage associated with water loss may be properly excluded.

Existing Quantification Methods for Measuring GHG Fluxes from Peatlands

Three common proxy measures for GHG fluxes from peatlands:

1. *Vegetation*
2. *Water level*
3. *Subsidence (level of the ground itself)*

Another option is utilizing data from direct sampling.

It appears that there are three main parameters that are currently used as suitable proxies for estimating GHG fluxes from peatlands - water level, subsidence (the level of the ground itself) and vegetation. These may be used interchangeably and sometimes in unison, depending on local conditions and available data. It is worth noting that the FWS has developed Wetlands Mapping Standards, which would ideally be taken into consideration and utilized where possible/appropriate.[51] The use of GIS imagery to identify land/vegetation characteristics in project areas is considered an accurate, reliable and cost effective means to model GHG fluxes from peatlands. There are also various sources for soil carbon data, obtained from direct

[49] *Wetland Restoration Methodology Framework (WR-MF)*, WR Methodology Module, American Carbon Registry, pg.14. http://americancarbonregistry.org/carbon-accounting/WR-MF.pdf
[50] Discussions with FWS staff, January 2013.
[51] *Wetlands Mapping Standard*, Federal Geographic Data Committee, Wetlands Subcommittee, July 2009. http://www.fws.gov/wetlands/Documents/FGDC-Wetlands-Mapping-Standard.pdf

measurement of soils (e.g. the NRCS soil survey). The following table provides a summary of current tools and methods used to quantify GHG emissions from peat projects.

SSR	Quantification Method	Tools Used	Applicable in U.S.
CO_2 from peat	Subsidence	Direct measurement and existing literature	Likely sufficient data available for some areas
CO_2 from peat	Water level modelling	GIS 20 modelling – LiDAR, SRT data; Water modelling tool such as SIMGRO – DRAINMOD	SIMGRO is not validated for U.S. at present – further tools need to be identified; A modified version of DRAINMOD appears to have been adopted by Duke University for modelling GHG fluxes in peatlands in NC
CO_2 from peat	Vegetation modelling	GESTs + existing data on project area vegetation GHG fluxes	Likely sufficient data available for some areas / vegetation and land strat types
CO_2 from peat	Direct sampling	NRCS Soil Survey online database tool	YES – likely geographically limited
CH_4 from peat	Direct soil GHG modelling	DNDC - possibly other methods / tools	Likely sufficient data available for some areas

Vegetation Mapping

The utilization of vegetation mapping for peat GHG flux modeling is the approach adopted under the VCS *Baseline and Monitoring Methodology for the Rewetting of Drained Peatlands Used for Peat Extraction, Forestry or Agriculture Based on GESTS* methodology, to be discussed in more detail below. The GEST approach utilizes fine scale GIS modeling, in combination with existing data sets on GHG fluxes associated with known land types, as proxy measure. Project developers identify the Greenhouse gas Emissions Site Types (GESTs) present in the project area, assess the pre-project distribution of those GESTs, derive time series predictions for how these will evolve over the life of the crediting period and then determine annual GHG emissions per stratum for the crediting period.

The use of vegetation as a measurement proxy has been found to not be effective in some types of peatlands. In such circumstances, the VCS GEST methodology utilizes water level modeling as a supplement. A further limitation of the GEST approach is its inability to model tree growth or CH_4 emissions from peatlands.

It would appear that the DNDC model may be suitable for modeling CH_4 emissions from peatlands, as this model is currently being used for that purpose in the development of further modeling tools for use in Finland.[52]

Water Level Modeling

Water level modeling is utilized both as a primary means to model peat GHG fluxes and also as a secondary means, to be used as a backup to vegetation based modeling. The VCS *Rewetting of Drained Tropical Peatlands in Southeast Asia* methodology, discussed further below, utilizes a tool named SIMGRO to model water levels in peatlands. Unfortunately SIMGRO is not calibrated for use in the U.S. It is unclear whether alternative tools for water modeling are currently available for use in the U.S. This particular VCS methodology also uses remote

[52] See http://www.metla.fi/hanke/7114/index-en.htm.

sensing imagery to develop spatially explicit 3D maps, in order to stratify the project boundary into land cover classes. These maps can be created using the LiDAR digital terrain model, or estimated from radar data, including data from the Shuttle Radar Topography (SRT) Mission. Jet Propulsion Lab staff brought up both of these types in discussions with the Reserve regarding how they may be able to assist with modeling/MRV, etc.

Land Level (Subsidence) Modeling

The VCS *Baseline and Monitoring Methodology for Avoiding Planned Deforestation of Undrained Peat Swamp Forests* uses measurements of the land surface to model peat depths and hence GHG fluxes. This is similar to the approach above, however water levels are measured on site.

Direct Soil Sampling

The Reserve Forest Project Protocol Version 3.3[53] has adopted a methodology for accounting for soil carbon stocks in project areas, including for histosols. In relation to the FPP itself, accounting for soil carbon is limited to instances of avoiding conversion of project areas from forest to agricultural land use. The existing FPP soil carbon methodology could be useful for estimating baseline soil carbon stocks for peat project areas.

The FPP utilizes an approach whereby data is obtained on project soil carbon stocks using an online NRCS soil database and associated software. Project developers can go onto a NRCS website, plot out their project area and estimate existing soil carbon levels. If data is not available for a project area, then project developers are allowed to estimate soil carbon levels using alternative sources of data. NRCS data is then supplemented with data from direct soil sampling within the project area. Soil samples must be extracted and sent to a laboratory with expertise in analyzing soil carbon and physical properties. A specific methodology is laid out for the laboratory sampling itself. From there, project developers must calculate the total carbon per acre of project area. The FPP goes on to ask project developers to quantify the effects of project activities on soil CO_2 levels, based on default values for net emissions associated with various management activities. At this point it might be possible to introduce the VCS default peat depletion value (or perhaps similar alternative values from scientific literature), set at 4.5 cm/year,[54] which is said to be a conservative estimate of peat depletion rates. A combination of these values could be used to model the expected depletion of peat in the baseline degraded peat state. Alternatively, project developers could be asked to repeat the soil sampling exercise at the beginning and end of a reporting period, in order to get more accurate estimates for project soil carbon stock changes.

[53] Available at http://www.climateactionreserve.org/how/protocols/forest/dev/version-3-3/.
[54] Taken from the VCS methodology, *Rewetting of Drained Tropical Peatlands in Southeast Asia*.

4 Existing Methodologies

As mentioned above there are several VCS methodologies, at various stages of approval, which target GHG emission reductions from peatlands. There is also an ACR protocol that focuses on the restoration of degraded deltaic wetlands of the Mississippi Delta.

Vegetation Modeling

VCS *Baseline and Monitoring Methodology for the Rewetting of Drained Peatlands Used for Peat Extraction, Forestry or Agriculture Based on GESTS*

This methodology focuses on rewetting of land that was drained and where the current land is no longer profitable (i.e. to avoid gaming, whereby peatland is first drained and then rewetted, in order to gain carbon revenues). The methodology uses vegetation as a proxy measure for peat GHG fluxes, and also allows for accounting for emissions from woody biomass changes and from improved fire management.

Vegetation is considered a good proxy measure for peat GHG fluxes because it is a good measure for water levels and because vegetation is crucial and directly responsible for GHG emissions through its role in supplying organic matter for CO_2 and CH_4 formation and influencing peat moisture (by providing shade and evapotranspiration).[55]

Emissions estimation is based on GHG Emissions Site Types (GESTs), which essentially consists of utilizing high grade GIS mapping to identify land/vegetation characteristics and then employing data sets for known GHG fluxes from those land and vegetation types. The use of this methodology is currently restricted to tropical areas, however the underlying methodologies would be applicable in the U.S., provided site conditions and appropriate data were available. The GEST approach focuses on CO_2 emissions from the land and therefore does not account for CH_4 fluxes that may occur in the transient phases after rewetting, nor does it account for fluxes in carbon stores in woody biomass. Despite this, the methodology does allow for the accounting of emissions reductions from woody biomass and CH_4, albeit through the application on (unspecified) further modeling tools or appropriate regional data. It is worth noting that the DNDC model is currently being used to model CH_4 emissions associated with peatlands.

This methodology allows for concurrent activities to occur in concert with rewetting, which include forestry, nature conservation/recreation and interestingly agriculture. There is no explanation as to what types of agriculture may be permitted, though the methodology does expressly prohibit the use of synthetic N fertilizers. In practice, this may be included to encourage or permit the use of paludiculture (the sustainable cultivation of biomass that thrives in wetlands), a practice that is already used to some extent in peatland protection priority areas such as Indonesia.[56]

[55] Couwenberg et al. (2011). *Assessing GHG emissions from peatlands using vegetation as a proxy*. Hydrobiologia.
[56] Wichtmann and Wichmann (2011). *Environmental, Social and Economic Aspects of a Sustainable Biomass Production*. Journal of Sustainable Energy & Environment, Special Issue, 77-81.

Water Level Modeling

VCS *Rewetting of Drained Tropical Peatlands in Southeast Asia*

This VCS methodology focuses on activities that involve the establishment of permanent or temporary structures within drainage canals to affect rewetting, in tropical peatlands. Project emissions are estimated based on modeled water levels, and include CO_2 from peat oxidation and CH_4 from anaerobic decomposition due to rewetting.

This methodology requires the use of spatially explicit digital terrain modeling to map out project areas. Remote sensing imagery tools such as LiDAR are used to stratify the project boundary, breaking it up into land classes. A second tool, SIMGRO, is then used to model water levels both above and below the surface. SIMGRO is not calibrated for use in the U.S., though this may be possible. It also may be possible for the Reserve to identify suitable alternative water modeling tools, appropriate for use in the U.S.

This methodology comes the closest to using a standardized approach to baseline setting. The methodology uses standardized applicability criteria for determining appropriate baseline scenarios, whereby demonstration of having met the applicability criteria equates to having demonstrated that an appropriate baseline scenario has been employed. There is also a general statement in the methodology to the effect that, unless regulations are present to restore the area, such project activities would typically be considered additional. However, the VCS additionality tool must still be applied. The combination of standardized baseline scenario applicability, with a tacit assumption of additionality, if applicability conditions are met, is akin to a standardized approach to additionality.

The methodology allows for the modeling of CH_4 emissions, using simple formulas and IPCC default emission factors, and allows for substitution of more accurate data where available. Several concepts, such as how to address leakage, should be applicable or adaptable to U.S. conditions. Total emissions reductions are limited by peat depletion time, which is essentially the time it would take for all the peat to be depleted, or for water levels to reach a stable state.

Peat Subsistence Modeling

VCS *Baseline and Monitoring Methodology for Avoiding Planned Deforestation of Undrained Peat Swamp Forests*

The third VCS methodology focuses on production forests, and not surprisingly offers the most flexibility with respect to the means to account for woody biomass. This methodology separates emissions reductions from different activity types and has different carbon accounting methods, accuracy thresholds and discounting procedures for each. Project peat emissions are calculated based on peat subsidence and water level modeling. Woody biomass baseline levels are calculated on legally approved conversion rates or empirically measured historical deforestation rates in the project or reference area.

Avoided peat conversion is based on measurements of water table in the project area and expected drainage under the project scenario. Carbon uptake through assisted natural regeneration is calculated completely separately using the most recent version of appropriate afforestation methods, and avoided deforestation is based on the classification and stratification of land in discrete classes or forest strata. In the same way, the Reserve may be able to develop a modular approach, utilizing existing forestry accounting methods to account for relevant woody biomass changes.

ACR Restoration of Degraded Deltaic Wetlands of the Mississippi Delta

ACR has developed a *WR Methodology Module: Wetland Restoration Methodology Framework (WR-MF)*. The methodology is used to quantify GHG emission reductions from wetlands restoration projects on both forested and non-forested wetlands, from fresh to saline conditions, although at present it is limited to the Mississippi Delta (to be expanded in future). The methodology is not applicable to peatlands; however, there are elements that may nonetheless be useful for informing peat protocol development.

In ACR's words, the WR-MF has a basic modular structure providing the generic functionality of a wetland restoration offset project baseline and monitoring methodology. Projects are divided into two broad activity types: WR activities limited to assisted regeneration, seeding, or tree planting, and WR activities that include some rewetting. Under both project types, project developers can assume either constant or degrading wetland baseline conditions. Projects can be credited up to a maximum of 40 years.

In terms of additionality, the methodology uses a practice-based Performance Standard and a regulatory additionality test. The performance standard essentially stipulates that based on the rate of wetlands restoration in Louisiana, the practice is not common practice. Therefore, any project meeting the applicability conditions will be deemed additional, without having to apply any implementation barrier analysis.

Projects involving forestry activities must comply with all requirements of the ACR Forest Carbon Project Standard (AR, IFM and/or REDD categories), although there is more flexibility regarding eligibility criteria. Applicability explicitly extends to both the private and public sectors, including Federal government entities, providing project developers demonstrate eligibility of project activities and clear land/offset title.

The methodology contains a restoration cost estimate of between $8,000 to $60,000 per acre depending on the restoration technique.

5 Conclusion

The emission reduction potential of a U.S. peatland restoration protocol is significant, and existing tools, methods, and primary data would make the development of a suitable protocol feasible and relatively simple. Initial project estimates show that projects utilizing such a protocol could generate sufficient revenues to make some activities economically feasible, while remaining additional to "business as usual."

By adding existing methodology components in a modular fashion, including forest carbon accounting along with peatland restoration activities appears to be tested and effective.

In terms of additionality, despite multiple and complex existing regulatory means to protect peatlands and relatively low rates of national wetlands loss, it appears that it will be feasible to develop multiple PST standards targeted to specific geographical regions, types of peatlands and types of activity, for both avoided conversion of peatlands and the restoration (rewetting) of degraded peatlands. More specifically, it may be feasible to develop multiple targeted PSTs based on the following general observations:

> *Regional wetlands losses are concentrated in areas where peatlands are prevalent – making an objective conversion PST standard, for those areas, potentially feasible.*
>
> *Current wetlands reestablishment/new creation is concentrated (59%) on agricultural land – making a simplified PST standard excluding agriculture potentially feasible. However, most peat restoration opportunities will be on agricultural lands – making a differentiated PST or alternative method to include such activities desirable.*
>
> *Current wetlands reestablishment/new creation may not have ecological integrity necessary to promote peatland GHG benefits – making a PST that prevents conversion of peatlands into other types of wetlands potentially feasible.*
>
> *Further analyses may demonstrate certain types of wetlands are at greater threat, in certain areas, to certain activities – making further targeted PST standards potentially feasible.*

It may also be useful for the Reserve to adopt and possibly adapt the Forest Project Protocol's means for assessing conversion threats, for use in a peatlands methodology.

Based on these and further factors, it would appear that the development of a Reserve protocol for peatland restoration would be feasible and provide significant GHG and wider co-benefits.