

SUPPLEMENT: Howland Forest, ME, USA: Multi-gas flux (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) social cost product underscores limited carbon proxies

**Table S1.** CAR681 and CAR1161 Project Links.

Project ID	CAR681	CAR1161
ARB ID	NA	CAFR5161
Project Developer	<a href="#">Northeast Wilderness Trust</a>	<a href="#">Northeast Wilderness Trust</a>
Project Owner	<a href="#">Northeast Wilderness Trust</a>	<a href="#">Northeast Wilderness Trust</a>
Project Name	<a href="#">Howland Research Forest</a>	<a href="#">Forest Carbon Partners - Northeast Wilderness Trust - Howland Research Forest</a>
Offset Project Operator	NA	Northeast Wilderness Trust
Authorized Project Designee	NA	Forest Carbon Partners, L.P.
Project Type	Improved Forest Management	Improved Forest Management - ARB Compliance
Status	<a href="#">Transitioned</a>	<a href="#">Registered</a>
ARB Project Status	Not ARB Eligible	Active ARB Project
Project Site Location	Penobscot County	Penobscot County
Project Site State	MAINE	MAINE
Total Number of Offset Credits Registered	48852	7762
Project Listed Date	12/19/2013	2/26/2015
Project Registered Date	3/13/2015	3/8/2019
Documents	<a href="#">View</a>	<a href="#">View</a>
Data	<a href="#">View</a>	<a href="#">View</a>
Project Website	<a href="http://www.forestcarbonpartners.com">www.forestcarbonpartners.com</a>	<a href="http://www.forestcarbonpartners.com">www.forestcarbonpartners.com</a>

**Table S2. CAR681 Project Emission Reductions and Issued Offset Serial Numbers.**

Action	Date Issued	Status	Vintage	Quantity of Offset Credits	Quantity of Offset Credits to Buffer Pool	Issued Quantity	Reporting Period Begin	Reporting Period End	Offset Credit Serial Numbers	Buffer Offset Credit Serial Numbers
<a href="#">View</a>	3/13/2015	Issued	2013	834	199	834	1/1/2013	12/31/2013	CAR-1-US-681-25-467-ME-2013-1697-1 to 834	CAR-1-US-681-25-467-ME-2013-1698-1 to 199
<a href="#">View</a>	3/13/2015	Issued	2012	834	199	834	1/1/2012	12/31/2012	CAR-1-US-681-25-467-ME-2012-1699-1 to 834	CAR-1-US-681-25-467-ME-2012-1700-1 to 199
<a href="#">View</a>	3/13/2015	Issued	2011	834	199	834	1/1/2011	12/31/2011	CAR-1-US-681-25-467-ME-2011-1701-1 to 834	CAR-1-US-681-25-467-ME-2011-1702-1 to 199
<a href="#">View</a>	3/13/2015	Issued	2010	834	199	834	1/1/2010	12/31/2010	CAR-1-US-681-25-467-ME-2010-1703-1 to 834	CAR-1-US-681-25-467-ME-2010-1704-1 to 199
<a href="#">View</a>	3/13/2015	Issued	2009	834	199	834	1/1/2009	12/31/2009	CAR-1-US-681-25-467-ME-2009-1705-1 to 834	CAR-1-US-681-25-467-ME-2009-1706-1 to 199
<a href="#">View</a>	3/13/2015	Issued	2008	35,299	8,388	34,654	10/8/2008	12/31/2008	CAR-1-US-681-25-467-ME-2008-1707-1 to 34654	CAR-1-US-681-25-467-ME-2008-1708-1 to 8388
<a href="#">View</a>	3/13/2015	Issued	2008	35,299	8,388	645	10/8/2008	12/31/2008	CAR-1-US-681-25-467-ME-2008-1696-1 to 645	

<https://thereserve2.apx.com/mymodule/reg/TabProjectEmissions.asp?r=111&ad=Prpt&act=update&type=PRO&aProj=pub&tablename=cr&id1=681>

**Table S3. CAR1161 Project Emission Reductions and Issued Offset Serial Numbers**

Action	Date Issued	Status	Vintage	Quantity of Offset Credits	Quantity of Offset Credits to Buffer Pool	Issued Quantity	Reporting Period Begin	Reporting Period End	Offset Credit Serial Numbers	Buffer Offset Credit Serial Numbers
<a href="#">View</a>	3/8/2019	Issued	2017	6,910	0	6,910	7/16/2015	7/15/2017	CAR-ROC-US-1161-125-467-ME-2017-5704-1 to 5583	CAR-ROC-US-1161-125-467-ME-2017-5705-1 to 1327
<a href="#">View</a>	10/9/2019	Issued	2017	852	0	852	7/16/2015	7/15/2017	CAR-ROC-US-1161-125-467-ME-2017-5852-1 to 688	CAR-ROC-US-1161-125-467-ME-2017-5853-1 to 164

<https://thereserve2.apx.com/mymodule/reg/TabProjectEmissions.asp?id1=1161&ad=Prpt&act=update&sBtn=&r=111&Type=PRO&tablename=cr&aProj=pub>

**Table S4. CAR681 and CAR1161 Online Project Documents**

Doc #	Vintage	CAR681	Document Type	Category	Upload Date	Uploaded By
1	2014	<a href="#">CAR-Forestry_NF_Howland_FinalVerificationReport_031115.pdf</a>	Verification Report	Verification	3/11/2015 19:43	SCS Global Services
2	2008	<a href="#">CAR_NF_Howland_VerificationStatement_v3-0_120214.pdf</a>	Verification Statement	Verification	12/3/2014 19:46	SCS Global Services
3	2008	<a href="#">Howland-Project-Design-Documents-2014-12-02.pdf</a>	Project Design Document	Verification	12/3/2014 1:29	Northeast Wilderness Trust
4	2008	<a href="#">NWT Project Developer Attestation of Voluntary Implementation_Howland.pdf</a>	Attestation of Voluntary Implementation	Verification	5/16/2014 21:21	Northeast Wilderness Trust
5	2008	<a href="#">NWT Project Developer Attestation of Regulatory Compliance_Howland.pdf</a>	Attestation of Regulatory Compliance	Verification	5/16/2014 21:21	Northeast Wilderness Trust
6	2008	<a href="#">NWT Project Developer Attestation of Title_Howland.pdf</a>	Attestation of Title	Verification	5/16/2014 21:20	Northeast Wilderness Trust
7	2008	<a href="#">Howland listing document submitted 121113_amended.pdf</a>	Project Submittal Form	Project Submittal	12/16/2013 22:06	Northeast Wilderness Trust
8	2008	<a href="#">Map -Howland Forest Carbon v2.pdf</a>	Physical Boundary Map	Project Submittal	9/22/2010 20:53	Northeast Wilderness Trust
		CAR1161				
9	2017	<a href="#">CAFR5161_OVS_16aug2019.pdf</a>	Offset Verification Statement	Verification	10/9/2019 21:49	The Climate Action Reserve
10	2017	<a href="#">Howland-COP-RP1-OPDR_20190306_Final.pdf</a>	Offset Project Data Report	Verification	3/7/2019 18:05	Northeast Wilderness Trust
11	2015	<a href="#">ARB IFM LISTING FORM HOWLAND_20150225_Final.pdf</a>	Offset Project Listing Information Form	Project Submittal	2/25/2015 18:59	Northeast Wilderness Trust
12*	2015	<a href="#">Howland Compliance Listing Documents.zip</a>	Offset Project Listing Information Form	Project Submittal	2/19/2015 21:55	Northeast Wilderness Trust

**Table S5 .** Summary of Howland Timeline for CAR681, CAR1161 and publication of US-Ho1,2,3 data based on Tables S2 – S4.

CAR681	US-Ho1,2,3	CAR 1161
	<p><b>1996</b> [40]; (NEE -210 gC m<sup>-2</sup> y<sup>-1</sup>;1996)</p>	
	<p><b>2004</b> [41]; (NEE - 174 ± 46 gC m<sup>-2</sup> y<sup>-1</sup>, 1996 - 2002)  [42]; (NEE forest regrowth, 2004 - 2008)</p>	
	<p><b>2007</b> ameriflux.com, fluxnet.org (<a href="https://ameriflux.lbl.gov/sites/siteinfo/US-Ho1#data-use-log">https://ameriflux.lbl.gov/sites/siteinfo/US-Ho1#data-use-log</a>; <a href="https://fluxnet.org/data/la-thuile-dataset/lathuile-data-summary/">https://fluxnet.org/data/la-thuile-dataset/lathuile-data-summary/</a>)</p>	
<p>10/8/2008 - 12/31/2008 [VINTAGE 2008 Offsets Issued - 34,654]</p> <p>10/8/2008 - 12/31/2008 [VINTAGE 2008 Offsets Issued - 645]</p> <p>Deed Restriction 10/8/2008</p>	<p><b>2008</b></p>	
<p>1/1/2009 - 2/31/2009 [VINTAGE 2009 Offsets Issued - 834]</p>	<p><b>2009</b></p>	
<p>1/1/2010 - 12/31/2010 [VINTAGE 2010 Offsets Issued - 834]</p> <p>Project Map, 9/22/2010 8:53:00 PM, NWT</p>	<p><b>2010</b></p>	
<p>1/1/2011- 12/31/2011 [VINTAGE 2011 Offsets Issued - 834]</p>	<p><b>2011</b></p>	
<p>1/1/2012 - 12/31/2012 [VINTAGE 2012 Offsets Issued - 834]</p>	<p><b>2012</b></p>	

<p>1/1/2013- 12/31/2013 [VINTAGE 2013 Offsets Issued - 834]</p> <p>Timber Inventory</p> <p>Howland Listing Document, 12/16/2013 10:06:00, NWT</p> <p>CAR681 First Reporting Period Ends 12/31/2013</p>	<p>[59] 2013</p>	
<p><u>VERIFICATION</u></p> <p>i. Attestation of Title, 5/16/2014 9:20:00, NWT</p> <p>ii. Attestation of Regulatory Compliance, 5/16/2014 9:21:00, NWT</p> <p>iii. Attestation of Voluntary Implementation, 5/16/2014 9:21:00, NWT</p> <p>iv. Project Design Document, 12/3/2014 1:29:00, NWT</p> <p>v. <u>VERIFICATION STATEMENT [VINTAGE 2008-2013]</u>, 12/3/2014 7:46:00, SCS</p> <p>CA Cap and Trade Regulation Section 95977(d) Deadline to Receive Offset Verification Statement, 11/30/2014</p>	<p>2014</p>	

<p><u>VERIFICATION</u></p> <p>i. Final Verification, SCS, 3/11/2015 7:43:00</p> <p>VINTAGE 2008-2013 Offsets Issued 3/13/2015</p>	<p><b>2015</b></p>	<p>7/16/2015-7/15/2017 [VINTAGE 2015-2017 Offsets Issued - 6,910]</p> <p>7/16/2015 - 7/15/2017 [VINTAGE 2015-2017 Offsets Issued - 852]</p> <p>Listed 2/26/2015</p> <p>2/19/2015 9:55:00 PM [Compliance Listing Documents, NWT VINTAGE 2015]</p> <p>25 Feb 2015 06:59 PM [ARB IFM Listing, NWT, VINTAGE 2015]</p>
	<p><b>2016</b></p> <p>(NEE 188 68 gC m-2 y-1, 1996 - 2014) (<a href="https://www.osti.gov/dataexplorer/biblio/dataset/1246061">https://www.osti.gov/dataexplorer/biblio/dataset/1246061</a>)</p>	
	<p><b>2017</b></p>	<p>CAR1161 First Reporting Period Ends 7/15/2017</p>
	<p><b>2018</b></p>	<p>CA Cap and Trade Regulation Section 95977(d) Deadline to Receive Offset Verification Statement, 6/14/2018</p>
	<p>[38] <b>2019</b></p>	<p>3/7/2019 6:05:00 PM [VERIFICATION, Offset Data Report, NWT, VINTAGE 2015-2017]</p> <p>Issued 3/8/2019</p> <p>6,910 Offsets Issued 3/8/2019</p> <p>10/9/2019 9:49:00 PM [VERIFICATION, Offset Statement, CAR, VINTAGE 2015-2017]</p> <p>852 Offsets Issued 10/9/2019</p>

**Table S6.** Absolute and percentage CARB yearly errors if the measurements from US-Ho1 were correct. Positive errors indicate CARB overestimations, while negative values are underestimations.

<b>Year</b>	<b>Absolute Error</b>	<b>Percentage error</b>
---	<i>tCO<sub>2</sub> y<sup>-1</sup> acre<sup>-1</sup></i>	<i>(%)</i>
2008	75.78	2257.54
2009	-6.09	-76.5
2010	-2.18	-53.88
2011	-0.65	-25.66
2012	-2.41	-56.26
2013	-2.24	-54.51
2014	No data	No data
2015	2.67	61.28
2016	2.04	40.9
2017	3.04	76.22

**Document S6.** Table S5 CARB-CAR, NEE timeline and documentation of critical errors.

Table S5 CARB-CAR, NEE Timeline. Table S5 shows the 2008 to 2019 CARB-CAR process timeline for CAR681 and CAR1161 including CAR regulatory system entry dates for offset issuance and document submission in support of offset creation, third-party validation and annual NEE data for the Howland Forest, coeval with CARB-CAR projects. Referring to CAR681, the first reporting period ending on 12-31-2013 (Year 2013), triggered an 11-month compliance period (i.e., ending 12-01-2014) for submission of a verification statement to CARB. Referring to the year 2014, the verification statement was recorded by CARB on 12/03/2014 rendering the offsets ineligible for issuance. The CAR681 timeline indicates that a timber inventory for CAR681 (and CAR1161) was completed in 2013 (raw data are not available), the same year that the project listing document (Table S4, Doc # 7) was recorded by CARB (Table S5, Year 2014). Referring to Table S5, Year 2017, the reporting period for CAR1161 offsets ended on 07/15/2017, triggering an 11-month compliance period (i.e., ending 06-15-2018) for submission of a verification statement. According to CARB documentation, the verification reporting was not uploaded to the CARB compliance registry system until 10/9/2018 rendering the 2015-2017 offsets ineligible for CARB issuance. The availability of directly measured CO<sub>2</sub> NEE data were available since 1996 followed by a seven-year annual record of NEE in 2004 [41]. At the time of the registration of the CAR681 full verification report (3/11/2015; Document # 1, Table S4), US-Ho1 NEE data were available from [40], [41], [58,59] covering the years 1996 to 2015 providing an independent source of forest carbon sequestration for independent evaluation of CARB-CAR data and carbon credit results. A single year of Howland NEE data, 1996, was cited, in error as described below. An accounting error is noted in the reported final Total GHG Reductions, Offset Verification Statement of 7,763 tCO<sub>2</sub> whereas the actual value was reported and issued as 7,762 tCO<sub>2</sub> (Table 3).

Table S5 Documentation of Critical Errors. Critical errors are noted in the stated interpretation and use of Howland NEE data. Referring to 2014 and 2012, the CARB-CAR documentation cites Hollinger NEE data, 1996 [40], and 2004 [41], in the Project Design Document (Table S4, Item 3, Fig. 17, p. 34) received by CARB on 12/03/2014, and a Supplemental Listing Document (Table S4, Item 12, Fig. 1, p. 9) received by CARB on 2/19/2015. The CARB-CAR documents refer to Fig. 7 of [40], [41] documenting a single year, 1996, of NEE data expressed as half-hourly net ecosystem carbon exchange in micromoles m<sup>-2</sup> s<sup>-1</sup>, referring to modeled and actual NEE data [41]. The CARB-CAR PDD in-correctly states that the seasonal variation of the CAR model (v3.2) was modified based on seven years of ecosystem-atmosphere CO<sub>2</sub>-flux measurements using the eddy covariance technique at the Howland AmeriFlux site. The Supplemental listing document repeats the same error citing and misstating the time interval of the Howland 1996 data. Both documents state, without providing details, that Table 12 (PDD, p. 34, Table 4, Document # 3) and Table 5 (Supplemental Listing), incorporates the Howland 1996 data; it is not known if the actual or modeled data were employed.