



# **GREENHOUSE GAS EMISSIONS ASSESSMENT ROADMAP FOR THE NORTH COAST RESOURCE PARTNERSHIP REGION**

**Guidance and Recommendations in Support of Technical Area 3  
of the Integrated Strategic Plan Effort**

**FINAL TECHNICAL REPORT**



Prepared by:  
Schatz Energy Research Center  
Humboldt State University, Arcata, CA 95521  
Technical Contact: Jerome Carman, [jerome.carman@humboldt.edu](mailto:jerome.carman@humboldt.edu)

Presented to West Coast Watershed  
Project Officer: Karen Gaffney

May 2017



# GREENHOUSE GAS EMISSIONS ASSESSMENT ROADMAP FOR THE NORTH COAST RESOURCE PARTNERSHIP REGION

## Guidance and Recommendations in Support of Technical Area 3 of the Integrated Strategic Plan Effort

Prepared by Schatz Energy Research Center  
Humboldt State University, Arcata, CA 95521  
Technical Contact: Jerome Carman, [jerome.carman@humboldt.edu](mailto:jerome.carman@humboldt.edu)

Presented to West Coast Watershed  
Project Officer: Karen Gaffney

May 2017

<b>Executive Summary</b> .....	<b>1</b>
<b>1 Technical Area 3 — GHG Emissions Accounting Roadmap</b> .....	<b>1</b>
<b>1.1 Defining Greenhouse Gas Accounting</b> .....	<b>2</b>
1.1.1 Choosing a GHG Emissions Assessment Approach .....	3
1.1.2 <i>Motivation</i> for Pursuing a GHG Emissions Assessment .....	3
1.1.3 <i>Boundaries</i> in GHG Emissions Accounting .....	4
1.1.4 <i>Classes</i> in GHG Emissions Accounting .....	4
1.1.5 <i>Focus Entities or Actions</i> in GHG Emissions Accounting .....	5
1.1.6 <i>Categories</i> in GHG Emissions Accounting .....	5
1.1.7 Determining <i>Relevancy</i> of Emissions Sources, Sinks and Activities in Greenhouse Gas Emissions Accounting .....	6
<b>1.2 NCRP Region Background Review</b> .....	<b>6</b>
1.2.1 Overview of GHG Assessment Efforts in the NCRP Region .....	6
<b>1.3 Local Government-Focused Recommendations Demonstrating the Potential of this Roadmap Design</b> .....	<b>9</b>
1.3.1 Recommended Protocols, Methodologies, and Tools .....	10
1.3.2 Recommended Data Sources .....	12
1.3.3 Best Practices .....	16
<b>1.4 Next Steps</b> .....	<b>16</b>
<b>References</b> .....	<b>17</b>

---

<b>Appendix A: Table of GHG Inventory and Footprint Protocols, Methodologies and Tools Used in the NCRP Region</b> .....	<b>19</b>
<b>Appendix B: Review of Assessed Protocols and Methodologies</b> .....	<b>22</b>
<b>Appendix C: Review of Assessed Tools and Models for Estimating Greenhouse Gas Emissions</b> .....	<b>24</b>

## EXECUTIVE SUMMARY

Climate change is our greatest current environmental challenge. In order to address climate change governments, organizations, companies and other entities are trying to reduce their greenhouse gas (GHG) emissions. There are numerous decision criteria that determine how an entity accounts for its GHG emissions. For example, entities often must decide whether to take an emissions production or consumption perspective, a decision that can lead to very different results and interpretations. The large number of decision criteria has resulted in the development of myriad protocols for assessing GHG emissions that differ in nuanced and technical ways. Because of this, there is a need for a standardized set of key decision criteria that can guide stakeholders toward choosing an appropriate protocol. This report establishes a set of key criteria, and utilizes it to develop a GHG emissions accounting roadmap for the North Coast Resource Partnership (NCRP) region.

An extensive literature review was conducted to identify features of existing GHG emissions accounting protocols. Drawing on this background information, this report briefly explains what a greenhouse gas emissions accounting protocol is, identifies a set of key decision criteria, and defines relevant terms. Next, a brief overview is provided of historic activity within the NCRP region related to quantifying and accounting for GHG emissions. Finally, two decision matrices are created using the key decision criteria. These matrices are then populated with recommendations that can assist stakeholders in their GHG assessment efforts; one matrix is populated with recommended protocols, methodologies, and tools, and the other with recommended data sources. The recommendations leverage past GHG accounting efforts in the NCRP region, and are targeted to the local government sector. However, the decision matrix structure can be populated with recommendations targeted to any stakeholder group.

This report is meant as a first step in establishing a roadmap to assist local stakeholders in choosing a GHG emission protocol. Results of this work present a useful yet still incomplete set of recommendations for local government stakeholders, and a set of key decision criteria with which additional decision matrices can be developed for other stakeholder groups. Key next steps are to reach out to stakeholders in the NCRP region to finish populating the two decision matrices with recommendations for local governments, and then to expand this roadmap to other stakeholder groups. Additional work could also include the development of best-practice recommendations that address aspects of GHG emissions accounting that are often poorly addressed in existing protocols.

## 1 TECHNICAL AREA 3 — GHG EMISSIONS ACCOUNTING ROADMAP

The goal of this section is to lay the groundwork for the development of a GHG emissions accounting Roadmap for stakeholders in the NCRP. This is to support the development of a regional plan that enhances the economic, environmental, and community vitality of the NCRP region. The strategy is to develop a Roadmap that completely leverages existing GHG emissions accounting Protocols and Methodologies that are differentiated by key aspects such as intended user, motivation, boundary, or action. Rather than define how to calculate, track, and report greenhouse gas flows, this Roadmap parses existing Protocols and Methodologies based on an extensive literature review of the discipline and of GHG emissions accounting efforts in the NCRP region. The end result is essentially a roadmap that guides stakeholders towards recommended existing and well established Protocols and Methodologies based on their specific needs and circumstances.

This document focuses on local government decision makers to demonstrate how this Roadmap can be used. The objective is to guide decision makers in the process of tying GHG emissions accounting efforts to policy and project implementation. However, other stakeholders in the public and private sectors should also find this Roadmap useful should it continue to be fleshed out in the future.

This report is structured as a technical document justifying the design of the Roadmap, with the demonstration of its use found in the tables towards the end of the document. Section 1.1 defines a number of key terms and concepts within greenhouse gas emissions accounting, with Section 1.2 setting the context within the NCRP region. Section 1.3 uses the key terms and concepts to develop a decision matrix through which recommendations for existing Methodologies and Protocols of interest to the region are provided. This decision matrix is also used to provide recommendations for data sources and best practices for utilizing the Methodologies and Protocols. Section 1.4 details potential future work for the continued development of this Roadmap.

In addition, a formatting standard is used in this document to indicate when a term is specifically defined in order to avoid confusion associated with variation and inconsistency in terminology in this field. Words that are *italicized* reference a specific group of terms within a concept that are defined in Section 1.1 (e.g. *motivation* is a specifically defined concept under which the two terms Inventory and Footprint are defined). Words

that are Capitalized reference a specific term within a concept that is defined in Section 1.1 (e.g. Inventory and Footprint are specifically defined *motivations*).

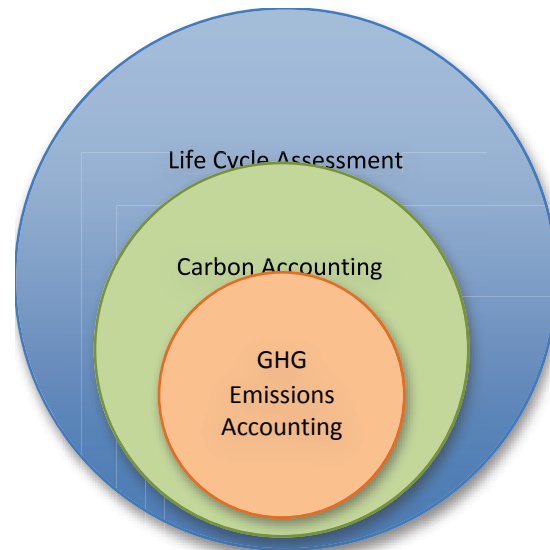
## 1.1 DEFINING GREENHOUSE GAS ACCOUNTING

Greenhouse gas (GHG) emissions accounting has a long and varied history rooted in Life Cycle Assessments (LCAs)[1], [2]. Life Cycle Assessments have been used since the early 1960s, originating in efforts by large corporations to identify environmental issues associated with product manufacturing as well as potential cost savings associated with untapped efficiencies in product production and distribution [3], [4]. Today LCAs have grown into complex and academically rigorous models that can focus on a wide range of environmental and social impact issues, of which today GHGs are an increasingly common and notable criteria.

Greenhouse gas emissions accounting has received significant attention and development in recent years due primarily to national government policy decisions and the establishment of carbon trading schemes. [8] Throughout its development a number of different accounting approaches and methodologies have emerged. For stakeholders interested in assessing GHG emissions it is important to understand these different approaches, the associated terminology, and also how GHG emissions accounting differs from LCAs.

There are two key differences between LCAs and GHG emissions accounting:

- GHG emissions accounting focuses specifically on GHG emissions while LCAs often assess a large number of environmental, social, and cost factors.
- GHG emissions accounting typically looks at a snapshot in time while LCAs typically consider emissions over a long period of time such as a typical useful life of a product, or over decades or centuries associated with total expected environmental, social, or cost impact.



**Figure 1: Relationship between Life Cycle Assessments (LCAs) and Greenhouse Gas (GHG) Emissions Accounting.**

Figure 1 summarizes at a high level how GHG emissions accounting relates to the broader field of LCAs. Both carbon accounting and GHG emissions accounting can be considered as sub-sets of life cycle assessment, with carbon accounting often broader in scope [8].

For this report, the term GHG emissions accounting is defined as the following which is used by [13]: “the assigning of responsibilities for [GHG] emissions and removals, in order to calculate debits and credits”. GHG emissions accounting has a lot in common with financial accounting [5], except that instead of energy and mass flows being represented as currency they are represented as GHGs. Note that this definition is not limited to carbon trading markets, but extends to any use that benefits from or requires debiting or crediting emissions.

The remainder of Section 1.1 is devoted to identifying and defining key terms and approaches in GHG emissions accounting that are used to establish a GHG emissions accounting Roadmap for the NCRP region. These terms represent key decision criteria that are then used to develop the structure of decision matrices (Table 3 and Table 4) which are the core of the Roadmap. It must be stressed that the field of industrial ecology<sup>1</sup> has not yet settled on definitions of many of the terms defined here.<sup>2</sup> The majority of those shown here are not necessarily considered standard definitions or groupings of the various Protocols or Methodologies

<sup>1</sup> The field of industrial ecology is a relatively new field that was catalyzed by the creation and development of life cycle analysis approaches. Visit the International Society for Industrial Ecology for more information at <http://www.is4ie.org/>.

<sup>2</sup> For example, see [8] for an exhaustive review of the multitude of definitions associated with term Carbon Accounting.

used for GHG emissions accounting. However, references have been provided to justify the definitions presented, and resources provided for further information. These defined definitions are summarized in Table 1 and are used as the foundation for this Roadmap.

**Table 1: Summary of specific terms that are defined and used to structure this Roadmap. This table was adapted from Table 1 in [1].**

Protocol, Methodology, Tool		
Motivation	Mandatory or Voluntary	
Boundary	Inventory or Footprint	
Class	Consequential	Attributional
Focus Entity or Action	Policy Project Product / Service	Community Organization Product / Service
Emissions Categorization	Sector Scope Direct / Indirect Source / Activity	
Relevance of Emissions Source, Sink or Activity	Ownership Operational Control Regulatory Authority Enforcement Budgetary / Equity Share	

### 1.1.1 Choosing a GHG Emissions Assessment Approach

At its most basic, an assessment of GHG emissions requires two sets of data: a set of GHG emissions intensity factors, and a set of quantifiable emissions source or activity data<sup>3</sup>. The product of these provides the GHG emissions quantities being sought after. Some assessment approaches provide GHG emissions intensity factors while others do not. Nearly all require the practitioner to provide the source or activity data, relying on their judgment to determine if data sources are applicable and reputable.

Before choosing an emissions assessment approach it is useful to tackle another set of terms used in this field that refer to materials used to implement an assessment of GHG emissions: Framework, Guidance, Standard, Protocol, Methodology, and Tool. Again there is variation in this field regarding the use of these terms, so the following definitions may not correlate with a particular document title or use of the term. However, distinguishing between these is critical to navigating through and choosing an existing emissions assessment approach, and recommended approaches are labeled accordingly. The following definitions build off the discussion on this topic found on page 19 in [14].

<sup>3</sup> Source or activity here refers to all possible *categories* of emissions. Examples include quantity of vehicle miles traveled, number of residential houses, amount of kilowatt-hours of electricity consumed, etc.

- **Protocol** (i.e Framework, Standard)<sup>4</sup>: Protocols establish “design principles” [14] for the development of an Inventory or Footprint, such as how to define and choose *motivation, boundary, class, focus entity or action*, how to report results, how to address uncertainty and accuracy, and requirements for completeness. In other words, a Protocol standardizes an emissions assessment approach. It is common that a protocol leaves significant leeway to the practitioner regarding which Methodology to use while other Protocols are specifically tied to a particular Methodology.
- **Methodology** (i.e. Guidance)<sup>5</sup>: Methodologies provide detailed guidance on calculating emissions, such as equations and data sets to use. Methodologies are typically designed to comply with one or more Protocols, although there are many custom methodologies that have been developed without following a particular Protocol.
- **Tool**: Tools are software designed to facilitate implementation of one or more methodologies. Generally this is either required if the methodology specifies numerical or statistical solutions, and/or is developed to make a methodology more accessible to practitioners.

It is common for existing materials to be both a Protocol and Methodology while other resources are limited to one or the other. Furthermore, the title of existing materials can lead to confusion based on the above definitions. For example, the U.S. Community Protocol [15] should be considered as both a Protocol and Methodology. The Greenhouse Gas Protocol® suite of tools aligns with the above definitions, but calls their Protocol documents “Standards” and their Methodology documents “Guidance”.

### 1.1.2 Motivation for Pursuing a GHG Emissions Assessment

An entity can have numerous motivations for assessing greenhouse gas emissions. For the purposes of this report motivations are grouped into two buckets:

- **Mandatory**: an entity is mandated to assess greenhouse gas emissions
- **Voluntary**: an entity wishes to voluntarily assess greenhouse gas emissions for any number of myriad reasons

<sup>4</sup> The terms Protocol, Framework, and Standard are treated similarly in relevant literature and so are considered synonymous here, with a preferential use of the term Protocol.

<sup>5</sup> The terms Methodology and Guidance are treated as synonymous by [14] and are also treated as such here, with a preferential use of the term Methodology.

The *motivation* for assessing emissions is important as it can significantly limit the methodology options available to the entity. Some entities that are mandated to assess emissions may be bound to a specific methodology, such as large polluters required to report their emissions annually to the California Air Resources Board (CARB) under California's Regulation for Mandatory Reporting of Greenhouse Gas Emissions<sup>6</sup>. Other entities mandated to assess emissions may have more leeway in the methodology they pursue. For example, projects pursued in California are subject to environmental review under the California Environmental Quality Act (CEQA). However, the current language of CEQA leaves the choice in methodology up to the lead agency (see §15064.4).

If the entity is pursuing a voluntary assessment the methodology choices may still be constrained. For example, if the entity is looking to voluntarily participate in a carbon trading scheme or product labeling program the methodology will be specifically defined. However, if the assessment is pursued for other non-regulatory reasons the number of options can be dizzying.

### 1.1.3 Boundaries in GHG Emissions Accounting

Greenhouse gas emissions accounting is a broad field in itself and, like the field of LCAs, is still in active development. Two main approaches to defining the *boundary*<sup>7</sup> of a GHG emissions accounting effort have emerged thus far[8]:

- **GHG Inventory:** this represents an emissions production perspective that looks at sources and sinks, generally within a defined geographic or fiscal boundary.
  - » A GHG Inventory is usually done for a snapshot in time, such as the emissions from a community for a given year.
  - » This approach aligns with a "polluter pays" concept where the entity that has a controlling share in a source or activity is responsible for the emissions.[8]
- **GHG Footprint:** this represents a consumption perspective, which looks at the emissions associated with the consumption of products and services, generally by a specific

geographic region, population group, or other community or organization.

- » GHG Footprints typically take a life cycle approach where the emissions of various consumed products and services are considered over some subset of or their entire effective useful life.
- » The total amount of products and services considered as consumed is generally associated with a snapshot in time, such as the consumption from a community for a given year.
- » See [19] for a review of GHG footprint approaches.

An example of how the results of these two *boundaries* can differ can be seen in the following comparison of the emissions of a fictitious community between two different years. If a cement company located within the geopolitical boundary of the community supplies cement to that community in the year 1990 yet closes in the year 2000,

- The total emissions accounted for in a GHG Inventory of the community may decrease from 1990 and 2000 because of the closure of the cement plant
- The total emissions accounted for in a GHG Footprint of the community may increase because the community is now consuming concrete imported from outside the community such that the emissions associated with the transport of the cement to the community is added to the community's footprint.

Review [20] for a recent GHG Footprint of the San Francisco Bay Area which includes a comparison to past GHG Inventories showing a 35% increase in emissions due primarily to the inclusion of those emissions associated with imported goods. Also, [21] provides a perspective on the two *boundaries*.

### 1.1.4 Classes in GHG Emissions Accounting

An Inventory or a Footprint can follow either of the following two *classes*<sup>8</sup>:

- **Attributional**<sup>9</sup>: this focuses on the absolute emissions associated with a particular entity or action. Typically, an Attributional approach quantifies direct emissions associated with a focus entity or action but does not quantify indirect, often market-induced, emissions such as land use change or co-product allocation.[26]

<sup>6</sup> See <http://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm> for additional information on this regulation.

<sup>7</sup> Note that the term *boundary* is used widely in relevant literature with significant variation in meaning. Often, it is used as an umbrella term to capture some or all of the terms defined here in Section 2.1. See [16] for a common example of this. Within existing methodologies the word is often used in conjunction with the terms "Organizational Boundary" and "Operational Boundary", typically when the focus entity is a community or organization (see [17] for a description and [18] for an example). However, in this report the term is very specifically defined as making the choice of conducting either an Inventory or a Footprint.

<sup>8</sup> Although the division of emissions assessments into these two classes is generally agreed upon, details regarding their definition and application are still hotly debated. For example, see [22], [23], and [24].

<sup>9</sup> From a Product / Service perspective, other names for the Attributional class include "accounting", "average", "book-keeping", "descriptive", "non-marginal", or "retrospective".[25]



- **Consequential**<sup>10</sup>: this focuses on the potential change in emissions associated with an activity or decision relative to a reference or baseline scenario. The consequential approach is often used to capture indirect market-induced emissions and as such is more often used to inform the potential impact of specific policy or business practice decisions.[26]

In essence the two *classes* are used to identify whether a GHG emissions accounting effort intends to identify the potential change in emissions rather than quantifying total emissions. The decision regarding which *class* to use depends on the *motivation*, goal and *focus* of the GHG emissions accounting effort.

### 1.1.5 Focus Entities or Actions in GHG Emissions Accounting

There are five main *entities or actions* that can define who or what the Inventory or Footprint will *focus* on[1]:

- Community
- Organization
- Policy
- Project (see CEQA definition of a project in §15378)
- Product / Service

The *focus entity or action* of an Inventory or Footprint significantly influences the applicable *class* as well as the various mass and energy flows that will be considered. For example, a GHG Inventory of the emissions of a community typically uses an Attributional approach while a GHG Inventory of the potential impact of a policy decision typically uses a Consequential approach<sup>11</sup>.

### 1.1.6 Categories in GHG Emissions Accounting

When considering sources or sinks of, and activities that result in, GHG emissions there are a few common *categories* used to bucket them. They are

- **Sector**: sector-based *categories* bucket emissions sources, sinks and activities into specifically defined sectors such as “built environment”, “transportation”, or “land use change”. Typically, sectors are defined in such a way as to align with how actions may be grouped in response to the results of an Inventory or Footprint.

- **Scope**: although the word scope is used loosely in various contexts in this field, the Greenhouse Gas Protocol®<sup>12</sup> applies a specific definition which many widely adopted protocols use. The Greenhouse Gas Protocol® defines Scope in the following way[27]:

- » Scope 1 Emissions: “All direct GHG emissions.”
- » Scope 2 Emissions: “Indirect GHG emissions from consumption of purchased electricity, heat or steam.”
- » Scope 3 Emissions: “Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. T&D losses) not covered in Scope 2, outsourced activities, waste disposal, etc.”

- **Direct / Indirect**: it is common to categorize emissions sources and activities as either direct or indirect. As a rule of thumb direct emissions are considered in both Inventories and Footprints, while Indirect emissions are considered in Footprints and may be considered to a limited extent in Inventories. The Greenhouse Gas Protocol® defines Direct and Indirect in the following way[27]:

- » Direct: “Direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity.”
- » Indirect: “Indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.”

- **Source / Activity**: ICLEI began encouraging the explicit categorization of emissions as a source or activity to help assist local policy and mitigation actions.[15] Version 1.1 of the U.S. Community Protocol defines Source and Activity in the following way:
  - » Source: “Any physical process inside the jurisdictional boundary that releases GHG emissions into the atmosphere (e.g., combustion of gasoline in transportation; combustion of natural gas in electricity generation; methane emissions from a landfill).”
  - » Activity: “The use of energy, materials, and/or services by members of the community

<sup>10</sup> From a Product / Service perspective, other names for the Consequential class include “change-oriented”, “market-based”, “marginal”, or “prospective”. [25]

<sup>11</sup> Note that Attributional GHG Inventories conducted for different years can also be compared against each other to obtain insight into a change in emissions. This is currently the common approach used in government climate action planning efforts, where a baseline Attributional GHG Inventory is completed for a community or local government organization, then updated regularly to assess the success of actions implemented between GHG Inventory years.

<sup>12</sup> The Greenhouse Gas Protocol® is a registered trademark of a suite of GHG accounting Protocols, Methodologies, and Tools developed and maintained by the World Resources Institute and the World Business Council for Sustainable Development. This suite is one of the most widely used globally, and many other Protocols and Methodologies that are targeted to specific audiences are rooted in the Greenhouse Gas Protocol®.

that result in the creation of GHG emissions either directly (e.g., use of household furnaces and vehicles with internal combustion engines) or indirectly (e.g., use of electricity created through combustion of fossil fuels at a power plant, consumption of goods and services whose production, transport and/or disposal resulted in GHG emissions)."

There are myriad additional ways that an emissions accounting effort can categorize emissions sources and activities if a particular protocol does not require a specific approach to categorization. The *categories* shown here represent those most commonly used.

### 1.1.7 Determining Relevancy of Emissions Sources, Sinks and Activities in Greenhouse Gas Emissions Accounting

One of the challenges with developing an Inventory or Footprint is identifying which emissions sources and activities are *relevant* to the *focus entity or action*.<sup>13</sup> This directly influences those sources and activities that the *focus entity or action* will claim responsibility for. Version 1.1 of the U.S. Community Protocol<sup>[15]</sup>, developed by ICLEI and based upon the Greenhouse Gas Protocol®, identifies the following different approaches for determining *relevancy*:

- **Ownership:** an emissions source, or key infrastructure associated with the emissions source, that is directly owned by the *focus entity*.
- **Operational Control:** an emissions source, or key infrastructure associated with the emissions source, that the *focus entity or action* has direct control over.
- **Regulatory Authority:** emissions sources or activities that the *focus entity or action* has "statutory authority [over and could] enact regulatory requirements or incentives that could significantly impact the generating activity or source, even if it chooses not exercise that authority." [15],
- **Enforcement:** the focus entity or action is primarily responsible for "enforcing regulations that could significantly impact the emission generating activity or its associated GHG emission source." [15]
- **Budgetary / Equity Share:** the focus entity or action "exercise[s] budgetary authority over the GHG emission source or [has] monetary influence over the community activity." [15]

<sup>13</sup> Note that many existing Protocols and Methodologies will use the term "boundary" to refer to this concept of *relevancy*. There is inherently substantial overlap between *boundary* and *relevancy*, as defined here, resulting in inconsistent use of the term "boundary" within this field. However, distinguishing between *boundary* and *relevancy*, as has been done in this report, is a valuable distinction that will assist the practitioner in identifying a proper approach that meets their needs.

It is also often the case that existing approaches will further distinguish between organizational and operational *relevancy*<sup>15,14</sup>. This is another useful perspective that a practitioner can keep in mind when deciding on the *relevancy* of sources and activities.

## 1.1 NCRP REGION BACKGROUND REVIEW

The counties of Del Norte, Siskiyou, Modoc, Humboldt, Trinity, Mendocino, Lake, and Sonoma comprise the NCRP region. This section provides a brief overview of historic activity within the state and local jurisdictions in the NCRP region related to quantifying and accounting GHG emissions.

### 1.1.1 Overview of GHG Assessment Efforts in the NCRP Region

There are numerous stakeholder groups that have pursued or are currently pursuing a GHG emissions assessment for a large number of reasons. Known groups in the NCRP region are summarized in Table 2. These groups are shown within the decision matrix defined in Table 3 in order to provide further context regarding who may want to use the recommendations in that matrix. For example, an incorporated city is a local government stakeholder. Many cities have pursued a voluntary GHG inventory for the entire incorporated community. Therefore, local government stakeholders may be interested in Protocols, Methodologies, and Tools recommended in Table 3 that have the following criteria:

- *Motivation:* Voluntary
- *Boundary:* Inventory
- *Class:* Attributional
- *Focus Entity or Action:* Community

The list of identified groups in Table 2 is not exhaustive, as efforts to identify a comprehensive list of stakeholder groups was limited by time and budget.

It is important to recognize that there are likely a large number of additional entities and groups that have pursued or plan to pursue a greenhouse gas emissions assessment. This report focuses on local government agencies, or entities bound to regulations that require an assessment of GHG emissions. However, there are a number of other voluntary reasons to conduct a GHG emissions assessment, including:

- Public or private entities intending to participate in a carbon trading scheme,

<sup>14</sup> See [15] and [14] for a good description of the distinction between operational and organizational.

- Public or private organizations interested in assessing the environmental impact of their operations, and
- Businesses interested in creating and marketing products with a lower environmental impact.

It is left to future work to integrate these additional entities and groups into this Roadmap.

The following section reviews the background of key efforts by local government agencies within the NCRP region. A review of efforts in the private and non-government sectors is left for future work.

**Table 2: Summary of stakeholder groups within the NCRP region that are known to have completed one or more greenhouse gas emissions accounting efforts. Areas with a question mark (?) represent those that were not researched in depth by the author and represent potential future research work. Areas with N/A are recommended as not applicable according to a review of current practices and literature as discussed in Section 1.1.**

Motivation	Boundary	Class	Focus Entity or Action				
			Community	Organization	Policy	Project	Product / Service
Mandatory	Inventory	Attributional	Local governments responding to local mandates	Large source polluters subject to annual monitoring by air districts <sup>1</sup>	N/A <sup>2</sup>	N/A18	?
		Consequential	N/A18	N/A <sup>3</sup>	Local governments responding to SB 375, or developing planning documents regulated by CEQA	Entities pursuing a project regulated by CEQA	?
	Footprint	Attributional	Local governments responding to local mandates	?	N/A18	N/A18	Fuel Suppliers
		Consequential	N/A18	N/A19	?	Entities addressing long-term impacts for CEQA compliance <sup>4</sup> Entities mandated under the Cap-and-Trade Compliance Offset Program <sup>5,6</sup>	?
Voluntary	Inventory	Attributional	Local Governments pursuing Climate Action Plans or similar	?	N/A18	N/A18	?
		Consequential	N/A18	N/A19	?	?	?
	Footprint	Attributional	Local Governments pursuing Climate Action Plans or similar	?	N/A18	N/A18	?
		Consequential	N/A18	N/A19	?	Entities conducting grant funded research projects Entities applying to the Cap-and-Trade Voluntary Offset Program	?

**1.1.1.1 Local Government**

Local government stakeholders are a key group interested in assessing GHG emissions. Over the last two decades regulatory drivers that involve assessing greenhouse gas emissions have come into play<sup>15</sup>. For local governments the key areas driving this are California Environmental Quality Act (CEQA) compliance, SB375 compliance, and the development of local legislation that considers and/or addresses GHG emissions. The motivation to quantify GHG emissions come from mitigation targets. Adaptation targets are generally less concerned with quantifying GHG emissions.

In CEQA, §15064.4, §15064.7, and Appendix G [31] are key sections containing language related to determining the significant impacts from GHG emissions<sup>16</sup>. Furthermore, SB375 has driven direct action by local transportation planning agencies regarding mitigating GHG emissions.

<sup>15</sup> For an excellent regulatory background regarding greenhouse gases at the international, federal, and state level, review §4.5.1.d in [30].

<sup>16</sup> Review §3.8.3.2 in [32] for a review of determining significance under CEQA through a local lens.

Legislative development has been another key driver motivated by state, federal and international momentum. Local governments are increasingly looking to understand GHG emissions in the context of policy development. Furthermore, CEQA also serves a motivating role through §15183.5 which provides guidelines for local jurisdictions on adopting GHG mitigating plans in a way that legally facilitates streamlining the CEQA compliance process.

Sonoma, Mendocino, and Humboldt counties have seen the most local government action in this space, with Sonoma County and the City of Arcata being recognized early leaders. Furthermore, the BAAQMD is the only entity in the NCRP region to issue guidance on GHG emissions significance thresholds<sup>17</sup> for CEQA compliance. The Mendocino AQMD explicitly recommends the use of the BAAQMD significance thresholds, while all other AQMDs in the region do not address significance thresholds. All AQMDs in the region provide some level of guidance regarding models and data sources on their websites.

Overall, while there has been significant early activity in the NCRP region regarding GHG accounting, the substantial outreach and training provided by the Green Communities project in 2012, a partnership between PG&E and ICLEI, catalyzed a recent widespread effort by jurisdictions in the region to quantify GHG emissions. The following paragraphs provide detailed background on past efforts in the three counties. Table 5 in Appendix A summarizes the GHG assessment methodologies used by various local government entities in the NCRP region.

**Sonoma County:** The Center for Climate Protection (CCP) in Sonoma County has been conducting GHG Inventories for the County since 2003 after the county joined the Cities for Climate Protection Campaign developed by ICLEI. This campaign included guidance on the development of a GHG Inventory. The CCP continues to use this guidance in order to facilitate consistent tracking and comparison with past inventories even though the methodology is now outdated<sup>18</sup> (for a detailed history of actions by County jurisdictions see [34]).

Partly in recognition of the fact that the GHG Inventory methodology space is dynamic, the Sonoma County Water Agency contracted with the CCP in 2010 to assess the current status of GHG tracking and make recommendations for future action.[34] Notably, they partnered with ICLEI Local Governments for

Sustainability - USA (ICLEI) who developed a GHG Inventory framework specifically for the County[35] as part of this project. However, shortly afterwards ICLEI released the U.S. Community Protocol which is very similar to the county-specific one that was developed. It appears the county-specific framework has not been explicitly implemented while the U.S. Community Protocol has been.

In 2016 the Regional Climate Protection Authority (RCPA) developed a climate action plan for the county. For this effort RCPA conducted a community-level inventory of the county, the methodology of which differs from that used by CCP, following primarily the ICLEI U.S. Community Protocol.<sup>19</sup>

For a good summary of the regional, county, and local regulatory setting as it relates to CEQA compliance and GHG emissions in Sonoma, see §3.8.2 in [32].

**Mendocino County:** Mendocino County has been very proactive regarding the inclusion of GHGs in local government planning. The Mendocino Council of Governments has been including GHG reduction as a motivation in transportation planning since 2000. [37] The 2004 City of Ukiah General Plan directly includes reductions in GHGs, two years before the passage of AB 32.

More recently, the 2009 County General Plan specifically discusses GHG reduction goals. In the same year the Ukiah Department of Planning and Building completed a city-wide GHG inventory. The development of climate action plans followed for both the City of Ukiah and City of Fort Bragg in 2012. The Community Development Commission of Mendocino County has been conducting GHG inventories for jurisdictions in the County through a Green Communities partnership with PG&E and ICLEI since 2012.

**Humboldt County:** With the exception of the City of Arcata, Humboldt County and jurisdictions within recently began actively inventorying GHG emissions due in large part to the proactive and effective Green Communities program implemented by PG&E and ICLEI.

The City of Arcata is an internationally recognized leader in sustainable community planning. Along with the County of Sonoma, the City joined the Cities for Climate Protection Campaign developed by ICLEI. The City completed their first GHG inventory in 2001, followed by an inventory update and a Greenhouse Gas Reduction Plan in 2006, and inclusion of GHG reduction goals in their General Plan in 2008. The City now works to align their GHG accounting efforts with

<sup>17</sup> As of the writing of this report BAAQMD is currently involved in a legal case regarding the resolution process used to adopt the guidelines. Since the case is "concerned whether CEQA applies to impacts of the environment on a project and is not relevant to the BAAQMD guidance regarding GHG emissions"[32], it is expected that the significance thresholds will not change, particularly in light of other AQMDs in the state issuing similar thresholds (e.g. see guidance provided by the South Coast Air Quality Management District [33])

<sup>18</sup> The methodologies used under the Climate Protection Campaign were modified and formalized into the Local Government Operations Protocol in 2009.

<sup>19</sup> Details regarding the differences in methodologies used can be found in the appendices of the climate action plan.[36]

those pursued by other county jurisdictions through efforts by the Redwood Coast Energy Authority (RCEA).

In 2005 RCEA partnered with the Schatz Energy Research Center in the development of a technical analysis for the Energy Element of the Humboldt County General Plan Update. This report noted greenhouse gas reductions as a motivation for pursuing alternative and renewable energy sources.

More recently jurisdictions in the County have begun pursuing climate action plans. The City of Trinidad developed a draft climate action plan in 2010, and in the same year the City of Fortuna included GHG reduction goals in their General Plan. In 2011 RCEA conducted a GHG Inventory for the Humboldt County Planning Department's draft Climate Action Plan which was released in 2012. In 2012 RCEA partnered with PG&E and ICLEI in the Green Communities program and began conducting GHG Inventories for all jurisdictions in the County. RCEA continues to update GHG inventories for jurisdictions on a regular basis. More recently other jurisdictions in the County have begun pursuing climate action plans.

### 1.1.1.2 *Private Sector*

There has been a global proactive effort within the private sector to quantify GHG emissions and environmental impacts associated with business operations and product supply chains. This has largely been driven by consumer interest via local government and community pressures in recent years. With the release of International Organization for Standardization (ISO) 14000 series standards focused on corporate and product sectors, the success of the Greenhouse Gas Protocol® suite of guidelines and tools, and the development of widely adopted modeling software, private sector accounting of GHG emissions is becoming increasingly common. As important as this background is, a review of activity in this sector within the NCRP region is left for future work.

### 1.1.1.3 *Non-Government Sector*

There has been significant activity around proactively assessing GHG impacts in the non-government sector for decades, likely highly correlated with the significant degree of environmental activism in the NCRP region. As important as this background is, a review of activity in this sector is left for future work.

## 1.1 LOCAL GOVERNMENT-FOCUSED RECOMMENDATIONS DEMONSTRATING THE POTENTIAL OF THIS ROADMAP DESIGN

Based upon the terminology defined in Section 1.1, the background review conducted in Section 1.2, a tabulation of methodologies used in region-specific documents such as climate action plans, environmental impact reports, and voluntary emissions reporting, discussions with local government representatives in the NCRP region, and a review of State policies and guidelines, a preliminary set of recommendations is provided that can assist an entity in navigating through the myriad options for accounting GHG emissions. Recommendations focus on local government stakeholders but are relevant to other stakeholder groups as well.

Recommendations are made using a "decision matrix" approach that leverages the terminology defined in Section 1.1. As such recommendations are presented in a table format. Multiple recommendations within a particular table cell are intended to be utilized collectively rather than choosing one.

Recommendations are primarily divided into two tables; Table 3 which focuses on existing methodology recommendations, and Table 4 which focuses on existing data source recommendations. Furthermore, an emphasis is made on methodologies and guidance documents that originate from or are used heavily by California entities, with only light mention of other methodologies and guidelines from national and international sources when appropriate.

It is worth noting that ICLEI has done a tremendous job developing and promoting their Protocols, Methodologies, and Tools to local government entities in the NCRP region. This results in noticeable bias towards their materials both in past efforts and in recommendations made here. However, the materials developed by ICLEI have followed a notably collaborative approach that leverages the international reach of ICLEI. Significant input from California, national, and international stakeholders has been incorporated by ICLEI, as can be observed in the acknowledgements section in [15]. This fact combined with the widespread use of ICLEI's Protocols, Methods, and Tools in California lends confidence that recommendations for their use are defensible.

This report is considered the starting point for the development of a complete Roadmap for the NCRP region that

standardizes how entities in the NCRP region approach GHG emissions assessment efforts by guiding the user towards existing Protocols rather than acting as a stand-alone Protocol<sup>20</sup>.

**1.1.1 Recommended Protocols, Methodologies, and Tools**

A summary of recommended Protocols, Methodologies, and Tools is shown in Table 3. Recommendations are aggregated by *focus entity or action*. Following Table 3, each of the Protocols, Methodologies, and Tools is briefly described and links are provided for relevant information resources. Additional information related to existing Methodologies and Protocols is provided in Appendix B, Table 6. Additional information regarding existing Tools is provided in Appendix C, Table 7.

**Table 3: GHG emissions accounting recommendations. Each recommendation is labeled as (P)rotocol, (M)ethodology, and/or (T)ool.**

Motivation	Boundary	Class	Focus Entity or Action				
			Community	Organization	Policy	Project	Product / Service
Mandatory <sup>7</sup>	Inventory	Attributional	NRM	NRM	N/A18	N/A18	NRM
		Consequential	N/A18	N/A19	NRM	CalEEMod (M,T) CAPCOA Quantifying GHG Mitigation Measures (P,M) BAAQMD CEQA Info (P) CalTrans SER (P) CARB Guidance for SB 375 (P) CARB Guidance for projects funded by GGRF (P,M) Local AHJ guidance	NRM
	Footprint	Attributional	NRM	NRM	N/A18	N/A18	NRM
		Consequential	N/A18	N/A19	NRM	CalEEMod (M,T) CARB Compliance Offset Protocols (P, M) GHGRx (P,M) BAAQMD CEQA Info (P) Local AHJ guidance	NRM
Voluntary	Inventory	Attributional	<ul style="list-style-type: none"> <li>Humboldt County GHG Emissions Inventory Tool (M,T)</li> <li>ICLEI U.S. Community Protocol (P,M)</li> <li>SEEC ClearPath (T)</li> </ul>	<ul style="list-style-type: none"> <li>LGO Protocol (P,M)</li> <li>EPA Center for Corporate Climate Leadership (P,M,T)</li> <li>Energy Star Portfolio Manager (T)</li> </ul>	N/A18	N/A18	?
		Consequential	N/A18	N/A19	<ul style="list-style-type: none"> <li>CAPCOA Quantifying GHG Mitigation Measures (P,M)</li> <li>ICLEI Recycling and Composting Protocol (P,M)</li> </ul>	<ul style="list-style-type: none"> <li>See Mandatory motivation recommendations</li> </ul>	?
	Footprint	Attributional	<ul style="list-style-type: none"> <li>ICLEI U.S. Community Protocol (P,M)</li> </ul>	<ul style="list-style-type: none"> <li>Greenhouse Gas Protocol® Corporate Accounting Standard (P,M,T)</li> </ul>	N/A18	N/A18	<ul style="list-style-type: none"> <li>Greenhouse Gas Protocol® Product Standard® (P,M,T)</li> </ul>
		Consequential	N/A18	N/A19	<ul style="list-style-type: none"> <li>Greenhouse Gas Protocol® Policy and Action Standard (P,M,T)</li> </ul>	<ul style="list-style-type: none"> <li>See Mandatory motivation recommendations</li> <li>Protocols from CARB-Approved Registries (P,M)</li> </ul>	?

<sup>20</sup> Protocols and Methodologies generally reference and integrate other existing documents, yet expand upon them to develop a unique stand-alone Protocol and/or Methodology. This document makes no effort to expand upon the content contained in the recommendations offered.

### 1.1.1.1 Community

- Humboldt County Greenhouse Gas Emissions Inventory Tool <sup>21</sup>
  - » Developed by the Redwood Coast Energy Authority specifically for assessing community inventories for jurisdictions in Humboldt County.
  - » Based upon the ICLEI U.S. Community Protocol.
  - » Output facilitates reporting to the Statewide Energy Efficiency Collaborative (SEEC) ClearPath California tool.
- ICLEI U.S. Community Protocol: <http://icleiusa.org/ghg-protocols/>
  - » Offered at no cost to cities and counties.
  - » Development was a collaborative between ICLEI, ILG, LGC, and the California Investor-Owned Utilities. The Climate Registry also contributed to its development.
  - » Integrates with the Statewide Energy Efficiency Collaborative (SEEC) ClearPath California tool that is freely available to, and developed specifically for, local government jurisdictions to facilitate tracking emissions and estimating the mitigation potential of actions that can feed into a climate action plan.
- SEEC ClearPath: <http://californiaseec.org/seec-clearpath/>
  - » Freely available online tool targeted to local government and Community GHG Inventories.
  - » Facilitates tracking Inventory updates, forecasting future emissions, and visualizing mitigation impact associated with proposed actions.

### 1.1.1.2 Organization

- Local Government Operations (LGO) Protocol: <http://icleiusa.org/ghg-protocols/>
  - » Freely available, and endorsed and used by The Climate Registry, CARB, CAPCOA, and many others.
  - » Widely used in the NCRP region
- EPA Center for Corporate Climate Leadership: <https://www.epa.gov/climateleadership>
  - » Targeted to the private sector.

- » Freely available suite of Protocols and Methodologies with a couple high-level tools.
- Greenhouse Gas Protocol® Corporate Accounting Standard: <http://ghgprotocol.org/>
  - » The Climate Registry assisted in the development of the Greenhouse Gas Protocol Scope 2 Guidance and Corporate Value Chain (Scope 3) Accounting and Reporting Standard.
  - » Freely available and widely used globally
- Energy Star Portfolio Manager: <https://portfoliomanager.energystar.gov/>
  - » Widely used online tool to benchmark and track energy consumption and GHG emissions of buildings.
  - » Built by the EPA Energy Star program
  - » Freely available

### 1.1.1.3 Policy

- California Air Pollution Control Officers Association (CAPCOA) Quantifying Greenhouse Gas Mitigation Measures: <http://www.capcoa.org/documents/>
  - » Freely available and widely used in California
  - » Highly detailed Protocol and Methodology for quantifying the potential impact of both GHG mitigation policies and actions.
  - » Widely utilized in California and recommended by all air quality districts
  - » The CalEEMod tool fully includes the Methodology from this document
- ICLEI Recycling and Composting Protocol: <http://icleiusa.org/ghg-protocols/>
  - » Compliments the U.S. Community Protocol, and allows for assessing the net GHG impact associated with recycling and composting efforts in a community.
- Greenhouse Gas Protocol® Policy and Action Standard: <http://ghgprotocol.org/>
  - » Collaboratively developed internationally, and as such is not focused on any particular geographic region
  - » Applicable to all scales of *focus entities or actions* from a local policy or project to one of international breadth.

<sup>21</sup> Contact the Redwood Coast Energy Authority to receive a copy of the Excel-based tool

### 1.1.1.4 Project

- California Emissions Estimator Model (CalEEMod): <http://www.capcoa.org/caleemod/>
  - » Developed for CAPCOA and recommended by all air quality districts in the NCRP region
  - » Replaces URBEMIS which many local government entities are familiar with
  - » Designed for assessing compliance with CEQA, NEPA, and local air quality standards
- CAPCOA Quantifying Greenhouse Gas Mitigation Measures: <http://www.capcoa.org/documents/>
  - » See description above
- Bay Area Air Quality Management District (BAAQMD) CEQA Information: <http://www.baaqmd.gov/plans-and-climate/california-environmental-quality-act-ceqa>
  - » The BAAQMD provides extensive and useful information regarding assessing GHG emissions for projects and CEQA compliance.
- CalTrans Standard Environmental Reference (SER): <http://www.dot.ca.gov/ser/>
  - » Provides handbooks of environmental guidance regarding transportation-related projects
  - » GHGs are addressed in Volume 1, Chapter 13
- CARB Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies (SCS) Pursuant to SB 375 [38] and CARB Summary of Off-Model Strategies [39]
  - » The CARB Description of Methodology provides additional Protocol-level information for MPOs and RTPAs regarding quantifying GHG emissions for Projects related to SB 375 goals and requirements. Significant discretion is left to the practitioner regarding what Methodology to use.
  - » The CARB Summary of Off-Model Strategies discusses approaches that other MPOs and RTPAs have taken to quantify the GHG emissions reduction impacts from projects that traditional transportation models are currently not able to quantify, such as ride sharing or intelligent transportation systems.
- CARB Guidance for Projects Funded with Greenhouse Gas Reduction Funds (GGRF): <https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm>
  - » Methodologies developed specifically for projects funded with Greenhouse Gas Reduction Funds which are raised through Cap-and-Trade auction proceeds.
  - » Although developed specifically for GGRF-funded projects, can be useful for assessing emissions associated with similar projects. Methods are typically reliant on CalEEMod and CAPCOA Quantifying Greenhouse Gas Mitigation Measures (see above).
- CARB Compliance Offset Protocols: <https://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm>
  - » Developed by CARB for assessing mitigated emissions for projects to be submitted for compliance under cap-and-trade
  - » Can be useful for assessing emissions associated with related projects even if those projects are not pursuing cap-and-trade compliance or credits
- Greenhouse Gas Credit Exchange (GHGRx): <http://www.ghgrx.org/>
  - » Developed by CAPCOA, specific to California
  - » Can be useful for assessing emissions associated with related projects even if those projects are not pursuing GHGRx emissions reduction credits
- Protocols from CARB-approved registries: <https://www.arb.ca.gov/cc/capandtrade/offsets/registries/registries.htm>
  - » There are currently three approved registries which are listed on CARB's website, each with their own set of Protocols
  - » Can be useful for assessing emissions associated with related projects even if those projects are not pursuing voluntary emissions reduction credits
- Local AHJ guidance
  - » As accounting for GHG impacts for CEQA compliance becomes more common local jurisdictions will be able to offer insight regarding Protocols, Methodologies, and Tools for projects within their local area

### 1.1.2 Recommended Data Sources

Data sources provide information regarding directly measured emissions, estimated emissions, and/or source or activity information that is needed to calculate emissions. Emissions factors are used to relate the amount of emissions associated with an *entity or action*. Usually emissions factors are represented as an intensity



that averages the quantity of emissions over a particular period of time from a given *entity or action*, such as the grams of carbon dioxide emitted per vehicle mile traveled. While directly measured emissions are used, most commonly, emissions factors are combined with source or activity information to reach emissions estimates.

The choice of data sources and emissions factors used in a GHG emissions assessment is a critical step as this directly impacts the assessments credibility, comparability, and repeatability of the assessment. Unfortunately, there is a plethora of data sources and emissions factors available from a wide array of sources ranging from reputable and rigorously vetted sources to online blog entries. The purpose of this section is to provide guidance to stakeholders in the NCRP region on this critical step.

Guidance will often be provided by a chosen Protocol, Methodology, or Tool regarding which data sources and emissions factors to use. However, many resources do not provide this level of detail, or leave the option to the practitioner to use a different data source if desired. Table 4 is provided to assist the practitioner in making a final choice regarding what information sources to use. Information sources are ranked using the following ratings:

- **Best:** Emissions factors that are as specific as possible to the focus entity or action are the most ideal. Examples include direct measurements, significant modification based on local data of inputs to a model that generates emissions factors, or emissions factors compiled from data directly applicable to the source or activity. Use this approach **ONLY IF** all of the following apply:
  - » Emissions factors come from a reputable source,
  - » It is reasonably expected that the source of the emissions factor is dependable for years to come, and
  - » The method used to create the emissions factor can, and is expected to, be repeated in the future.
- **Good:** Emission factors that are as specific to the geographic region, entity, or activity being considered in the assessment as possible. For example, an emissions intensity factor of CO<sub>2</sub>e/sq. ft. of commercial space created from a county-level survey is preferable to one created from a national-level survey.
- **Fair:** Sources to be used if there are no appropriate options rated as Good or Best. Typically these will be generic default or national-level averages. Note that the rating of “Fair” does not refer

to the reputability of recommended sources but on how appropriate or ideal they are.

Recommended data sources follow the same “decision matrix” approach. Recommended data sources are summarized in Table 4, and descriptions of these data sources along with relevant Internet links are provided in the following sections. Recommendations are organized into specific *categories*, where each *category* is defined as Direct by Sector (e.g., Built Environment, Transportation, Water/Wastewater, etc.), or Indirect. Note that often a Protocol, Methodology, or Tool will include default data sets. Unless bound to their use every effort should be made to utilize the data sources recommended in Table 4.

**Table 4: Summary of recommended sources for data and emissions factors to be used in a GHG emissions assessment. Question marks (?) indicate the need for future work.**

Categories – Sector and Direct / Indirect							
	Multiple Sectors	Direct – by Sector				AFOLU <sup>9</sup>	Indirect
		Built Environment	Transportation	Water / Wastewater	Solid Waste		
<b>Best</b>	CEQA §15364.5 <sup>10</sup>	<ul style="list-style-type: none"> <li>Local utility or CRIS</li> <li>CARB Facility GHG Emissions Visualization and Analysis Tool</li> </ul>	<ul style="list-style-type: none"> <li>Tools developed by regional AQMD</li> <li>CARB EMFAC Model + custom data input from regional transportation model</li> </ul>	<ul style="list-style-type: none"> <li>Local potable water and wastewater plant performance data coupled with Methodology-specific calculation guidance<sup>11</sup></li> </ul>	<ul style="list-style-type: none"> <li>CalRecycle SWIS and DRS</li> <li>Local waste characterization study</li> </ul>	?	<ul style="list-style-type: none"> <li>GREET</li> </ul>
<b>Good</b>	<ul style="list-style-type: none"> <li>CA-specific data in ICLEI U.S. Community Protocol</li> <li>EPA GHG Emissions Factors Hub</li> </ul>	<ul style="list-style-type: none"> <li>CAPCOA Quantifying GHG Mitigation Measures</li> </ul>	<ul style="list-style-type: none"> <li>EMFAC or CT-EMFAC<sup>12</sup></li> <li>CAPCOA Quantifying GHG Mitigation Measures</li> </ul>	<ul style="list-style-type: none"> <li>CA-specific data in ICLEI U.S. Community Protocol</li> </ul>	?	?	?
<b>Fair<sup>13</sup></b>	<ul style="list-style-type: none"> <li>National level data in ICLEI U.S. Community Protocol</li> <li>CAIT</li> <li>EPA CHIEF</li> </ul>	<ul style="list-style-type: none"> <li>eGRID</li> </ul>	<ul style="list-style-type: none"> <li>GREET</li> </ul>				

**1.1.2.1 Direct - Multiple Sectors**

There are many data sources that contain information across multiple emissions sectors. Although useful, often multi-sector data sets are not as preferred as sector-specific data sets.

- Best
  - » CEQA §15364.5
    - § Provides guidance regarding which greenhouse gases to consider
- Good
  - » CA-specific data in the ICLEI U.S. Community Protocol[15]
    - § Contains detailed data with sources cited that is specific to California energy and mass flows and emissions factors
- Fair
  - » National-level data in the ICLEI U.S. Community Protocol
  - » EPA Center for Corporate Climate Leadership GHG Emission Factors Hub: <https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub>
    - § Contains national average emissions factors across a broad range of sectors
  - » Climate Analysis Indicators Tool (CAIT): <http://cait.wri.org/>
    - § Contains global emissions data at the national scale
  - » EPA Clearinghouse for Inventories and Emissions Factors (CHIEF): <https://www.epa.gov/chief>
    - § Contains detailed criteria and hazardous air pollutant data, including federal compliance and emissions reporting data.

**1.1.2.2 Direct - Built Environment**

Built environment refers to energy consumption and mass flows associated with the construction and/or operation of stationary infrastructure such as buildings and roads.

- Best
    - » Local utility or Climate Registry Information System (CRIS): <https://cris4.org>
      - § Utilize these resources for obtaining emissions factors for utilities that provide electricity. Reporting to CRIS is voluntary so only a handful of utilities can be found in this database.
    - » CARB Facility GHG Emissions Visualization and Analysis Tool: [https://www.arb.ca.gov/ei/tools/ghg\\_visualization/](https://www.arb.ca.gov/ei/tools/ghg_visualization/)
      - § Provides geospatial access to GHG emissions reported by all mandated large polluters in California
  - Good
    - » CAPCOA Quantifying Greenhouse Gas Mitigation Measures: <http://www.capcoa.org/documents/>
      - § Contains detailed emissions factors and cited sources specific to California
  - Fair
    - » Emissions & Generation Resource Integrated Database (eGRID): <https://www.epa.gov/energy/eGRID>
      - § Contains subregion grid-scale emissions factors for the electricity sector.
      - § If the Protocol or Methodology being used by the practitioner does not contain guidance on the use of eGRID data, guidance can be found at <https://www.epa.gov/sites/production/files/2015-01/documents/adiem.pdf>
- specific to a particular fleet of any size. Use of EMFAC with default input data is recommended as Good, and use with customized inputs is recommended as Best.
- Good
    - » EMFAC or CT-EMFAC
      - § The use of EMFAC with default data inputs reflects state-wide average on-road vehicle fleet data from the eight municipal planning organizations in the state. CT-EMFAC was developed by CalTrans and UC Davis and provides a simplified interface version of EMFAC targeted specifically at transportation emissions analysis for CEQA conformity.<sup>22</sup>
    - » CAPCOA Quantifying Greenhouse Gas Mitigation Measures: <http://www.capcoa.org/documents/>
      - § Contains detailed emissions factors and cited sources specific to California
  - Fair
    - » Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (GREET): <https://greet.es.anl.gov/>
      - § This model estimates national average life cycle emissions associated with the transportation sector. It differentiates between direct and indirect emissions. Because the direct emissions reflect national averages it is preferable to use other sources recommended above. However, this is a highly recommended and industry leading resource for estimating indirect emissions for the transportation sector, and as such is rated as Best for the Indirect *category*.

### 1.1.2.3 Direct - Transportation

- Best
  - » Data and Tools developed by regional AQMD
    - § These include regional transportation models, model data informed by regional data, direct local measurement data, etc. Check with the applicable AQMDs for more information.
  - » CARB Emissions Factors (EMFAC) Model coupled with custom data input from regional transportation model
    - § The EMFAC model is a tool developed by CARB that estimates emissions from the transportation sector. Advanced use of this tool allows customized data inputs in order to create emissions estimates

### 1.1.2.4 Direct - Water and Wastewater

- Best
  - » Local data coupled with Methodology-specific guidance
    - § Many Methodologies specify exactly how to calculate emissions from the water and wastewater sectors based on locally collected information. If a particular Methodology does not provide this guidance, and allows freedom to choose the Methodology, it is recommended that the specified calculations in the U.S.

<sup>22</sup> As of the writing of this report the current version of CT-EMFAC does not comply with CEQA conformity requirements. The release of CT-EMFAC 5 is expected soon and will comply, pending CalEPA approval.

Community Protocol be used to convert local data into emissions estimates.

- Good
  - » CA-specific data in ICLEI U.S. Community Protocol [15]
    - § This is the same approach as above, but using the default data specific to California that is provided in the U.S. Community Protocol. If a particular Methodology does not provide calculation guidance, and allows freedom to choose the Methodology, it is recommended that the specified calculations in the U.S. Community Protocol be used to convert the CA-specific data into emissions estimates.

### 1.1.2.5 Direct - Solid Waste

- Best
  - » CalRecycle Solid Waste Information System (SWIS)
    - § Provides permitted throughput quantities for all solid waste and compost operations by County
    - § CalRecycle Disposal Reporting System (DRS) Jurisdiction Disposal and Alternative Daily Cover (ADC) Tons by Facility: <http://www.calrecycle.ca.gov/LGCentral/Reports/DRS/Destination/JurDspFa.aspx>
    - § Reported solid waste disposal data by all Cities and Counties in the state
  - » Local Waste Characterization Study
    - § Many waste management districts, industries, and organizations have had detailed characterizations studies conducted that can be used by Inventory and Footprint efforts to determine the composition of aggregated waste streams, such as those reported to the CalRecycle resources stated above, in order to assigned different emissions factors associated with different types of solid waste. This is preferable to the use of averaged state or national waste characterization numbers.

### 1.1.2.6 Direct - Agriculture, Forestry, and Other Land Use

An assessment of recommendations for this sector is left for future work.

### 1.1.2.7 Indirect

- Best
  - » Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (GREET): <https://greet.es.anl.gov/>
    - § This model estimates national average life cycle emissions associated with the transportation sector. It differentiates between direct and indirect emissions. This is a highly recommended and industry leading resource for estimating indirect emissions for the transportation sector, but is recommended as Fair for direct emissions.

### 1.1.3 Best Practices

To be developed under future work.

## 1.1 NEXT STEPS

This report lays the structural foundation upon which to build a robust GHG Emissions Accounting Roadmap for stakeholders in the NCRP region. Furthermore, an initial start on fleshing out this Roadmap is demonstrated via the recommendations made that focus on local government stakeholders. However, additional work is needed to complete this Roadmap in order to make it a sound reference.

Critical work needed to complete the development of this roadmap is as follows:

- Continue an in-depth review of additional resources specific to the local region.
- Continue engagement with regional stakeholders to seek input on recommendations to include.
- Fill in additional recommendations in Table 3 and Table 4 to complete these decision matrices.
- Pursue a peer-review process by stakeholders in the region to strengthen the design of this Roadmap

Additional work that is needed to flesh out this roadmap is as follows:

- Consider providing insight on choosing a voluntary trading scheme which could be helpful to public and private stakeholders
- Flesh out the background review and recommendations for the private and NGO stakeholder groups. Recommendations for these stakeholder groups will particularly benefit economic development, product branding, and local businesses by providing a tool for navigating a complex field with a lot of options

- Flesh out a section that provides best-practice recommendations which pull from existing sources. For example, best practices on the following would be valuable:
  - » How to choose a data source, elaborating on the Best, Good, Fair approach used above.
  - » Discuss required vs. recommended GHGs as well as near-term climate forcers.
  - » Discuss challenges with temporal consistency for carbon footprinting, particularly for biogenic emissions, and also for Consequential Protocols and Methodologies.
  - » Briefly touch on inventory and footprint principles (although these are well covered in existing materials): relevance, completeness, consistency, transparency, accuracy.[18] See [14] for detailed analysis and description of these principles.
  - » Briefly touch on quantifying uncertainty (although these are well covered in existing materials).

## REFERENCES

- [1] M. Brander, "Transposing lessons between different forms of consequential greenhouse gas accounting: lessons for consequential life cycle assessment, project-level accounting, and policy-level accounting," *J. Clean. Prod.*, vol. 112, pp. 4247–4256, Jan. 2016.
- [2] A. Russell, T. Ekvall, and H. Baumann, "Life cycle assessment — introduction and overview," *J. Clean. Prod.*, vol. 13, no. 13–14, pp. 1207–1210, Nov. 2005.
- [3] J. Guinée, "Life Cycle Sustainability Assessment: What Is It and What Are Its Challenges?," in *Taking Stock of Industrial Ecology*, R. Clift and A. Druckman, Eds. Cham: Springer International Publishing, 2016, pp. 45–68.
- [4] M. C. McManus and C. M. Taylor, "The changing nature of life cycle assessment," *Biomass Bioenergy*, vol. 82, pp. 13–26, Nov. 2015.
- [5] R. Matthews *et al.*, "Review of literature on biogenic carbon and life cycle assessment of forest bioenergy," *For. Res.*, 2014.
- [6] M. Z. Hauschild *et al.*, "Identifying best existing practice for characterization modeling in life cycle impact assessment," *Int. J. Life Cycle Assess.*, vol. 18, no. 3, pp. 683–697, Sep. 2012.
- [7] S. Hellweg and L. M. i Canals, "Emerging approaches, challenges and opportunities in life cycle assessment," *Science*, vol. 344, no. 6188, pp. 1109–1113, Jun. 2014.
- [8] K. Stechemesser and E. Guenther, "Carbon accounting: a systematic literature review," *J. Clean. Prod.*, vol. 36, pp. 17–38, Nov. 2012.
- [9] A. Levasseur, P. Lesage, M. Margni, L. Deschênes, and R. Samson, "Considering Time in LCA: Dynamic LCA and Its Application to Global Warming Impact Assessments," *Environ. Sci. Technol.*, vol. 44, no. 8, pp. 3169–3174, Apr. 2010.
- [10] J. Almeida, J. Degerickx, W. M. J. Achten, and B. Muys, "Greenhouse gas emission timing in life cycle assessment and the global warming potential of perennial energy crops," *Carbon Manag.*, vol. 6, no. 5–6, pp. 185–195, Nov. 2015.
- [11] J. G. Vogtländer, N. M. van der Velden, and P. van der Lugt, "Carbon sequestration in LCA, a proposal for a new approach based on the global carbon cycle; cases on wood and on bamboo," *Int. J. Life Cycle Assess.*, vol. 19, no. 1, pp. 13–23, Jan. 2014.
- [12] M. T. Ter-Mikaelian, S. J. Colombo, and J. Chen, "The Burning Question: Does Forest Bioenergy Reduce Carbon Emissions? A Review of Common Misconceptions about Forest Carbon Accounting," *J. For.*, vol. 113, no. 1, pp. 57–68, Jan. 2015.
- [13] A. Cowie, R. Eckard, and S. Eady, "Greenhouse gas accounting for inventory, emissions trading and life cycle assessment in the land-based sector: a review," *Crop Pasture Sci.*, vol. 63, no. 3, pp. 284–296, 2012.
- [14] ICF International, "Greenhouse Gas Emissions Inventory Methodology Guidance for State Transportation Departments," American Association of State Highway and Transportation Officials (AASHTO), Jul. 2011.
- [15] ICLEI - Local Governments for Sustainability USA, "U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions: Version 1.1." ICLEI - Local Governments for Sustainability USA, Jul-2013.
- [16] M. Brander and F. Ascui, "The Attributional-Consequential Distinction and Its Applicability to Corporate Carbon Accounting," in *Corporate Carbon and Climate Accounting*, S. Schaltegger, D. Zvezdov, I. A. Etxeberria, M. Csutora, and E. Günther, Eds. Springer International Publishing, 2015, pp. 99–120.
- [17] M. J. Franchetti and D. Apul, *Carbon Footprint Analysis: Concepts, Methods, Implementation, and Case Studies*. CRC Press, 2012.
- [18] World Resources Institute and World Business Council for Sustainable Development, "The

- greenhouse gas protocol: a corporate accounting and reporting standard - revised edition." 2013.
- [19] L. Čuček, J. J. Klemeš, and Z. Kravanja, "A Review of Footprint analysis tools for monitoring impacts on sustainability," *J. Clean. Prod.*, vol. 34, pp. 9–20, Oct. 2012.
- [20] C. M. Jones and D. M. Kammen, "A Consumption-Based Greenhouse Gas Inventory of San Francisco Bay Area Neighborhoods, Cities and Counties: Prioritizing Climate Action for Different Locations," *Bay Area Air Qual. Manag. Dist.*, Dec. 2015.
- [21] B. P. Weidema, M. Thrane, P. Christensen, J. Schmidt, and S. Løkke, "Carbon Footprint: A Catalyst for Life Cycle Assessment?," *J. Ind. Ecol.*, vol. 12, no. 1, pp. 3–6, Feb. 2008.
- [22] G. Finnveden *et al.*, "Recent developments in Life Cycle Assessment," *J. Environ. Manage.*, vol. 91, no. 1, pp. 1–21, Oct. 2009.
- [23] R. J. Plevin, M. A. Delucchi, and F. Creutzig, "Using Attributional Life Cycle Assessment to Estimate Climate-Change Mitigation Benefits Misleads Policy Makers," *J. Ind. Ecol.*, vol. 18, no. 1, pp. 73–83, Feb. 2014.
- [24] S. Suh and Y. Yang, "On the uncanny capabilities of consequential LCA," *Int. J. Life Cycle Assess.*, vol. 19, no. 6, pp. 1179–1184, Apr. 2014.
- [25] T. Rehl, J. Lansche, and J. Müller, "Life cycle assessment of energy generation from biogas—Attributional vs. consequential approach," *Renew. Sustain. Energy Rev.*, vol. 16, no. 6, pp. 3766–3775, Aug. 2012.
- [26] B. Lippke, E. Oneil, R. Harrison, K. Skog, L. Gustavsson, and R. Sathre, "Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns," *Carbon Manag.*, vol. 2, no. 3, pp. 303–333, Jun. 2011.
- [27] World Resources Institute and World Business Council for Sustainable Development, "FAQ | Greenhouse Gas Protocol." [Online]. Available: <http://www.ghgprotocol.org/calculation-tools/faq>. [Accessed: 27-Oct-2016].
- [28] California Natural Resources Agency, "Final Statement of Reasons for Regulatory Action - Amendments to the State CEQA Guidelines Addressing Analysis and Mitigation of Greenhouse Gas Emissions Pursuant to SB97," Dec. 2009.
- [29] K. Drude, *Planning Commission Staff Memorandum and Staff Report for Greenhouse Gas Emissions Threshold of Significance*. County of Santa Barbara, California, 2015.
- [30] Humboldt County Association of Governments, "Humboldt Regional Transportation Plan 2013/14 Update - Final Environmental Impact Report," Humboldt County Association of Governments, SCH# 2013102063, Jul. 2014.
- [31] California Association of Environmental Professionals, "2016 California Environmental Quality Act (CEQA) Statute and Guidelines." 01-Jan-2016.
- [32] ICF International, "Sonoma County Regional Climate Protection Authority Climate Action 2020: Community Climate Action Plan," Prepared for Sonoma County Regional Climate Protection Authority, Final Environmental Impact Report SC #2015092072, Jun. 2016.
- [33] South Coast Air Quality Management District, "Greenhouse Gases CEQA Significance Thresholds." [Online]. Available: <http://www.aqmd.gov/home/regulations/ceqa/air-quality-analysis-handbook/ghg-significance-thresholds>. [Accessed: 28-Oct-2016].
- [34] D. Erickson and A. Hancock, "Greenhouse Gas Emissions Tracking in Sonoma County: An Overview of Current Status and Recommendations for Future Action." Climate Protection Campaign, Sep-2010.
- [35] ICLEI, "Greenhouse Gas Emissions Tracking in Sonoma County: An Overview of Current Status and Recommendations for Future Action - Appendix E: Analysis of Community Inventory Methodologies," May 2010.
- [36] Regional Climate Protection Authority, "Climate Action 2020 and Beyond - Sonoma County Regional Climate Action Plan," Jul. 2016.
- [37] Janet M. Orth, "How to Prevent Pollution on the Beautiful North Coast with Zero Emissions Vehicles: Feasibility for Public Transit in a Rural Region," presented at the 14th National TRB Rural Public & Intercity Bus Transportation Conference - Rural Mobility Solutions for the 21st Century, 2000.
- [38] California Air Resources Board, "Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies (SCS) Pursuant to SB 375." Jul-2011.
- [39] California Air Resources Board, "Off-Model Strategies Adopted by California MPOs In Sustainable Communities Strategies as of April 29, 2016." Apr-2016.

## APPENDIX A: TABLE OF GHG INVENTORY AND FOOTPRINT PROTOCOLS, METHODOLOGIES AND TOOLS USED IN THE NCRP REGION

The methodologies listed in the following table do not represent a fully comprehensive list primarily because of the challenge with surveying across all stakeholder groups in the region. The table below focuses on local government agencies, and also includes a review of entities that have filed for voluntary carbon credits under existing carbon registries. Given that the ability to sort and search for carbon credit projects by project location is limited for some registries not all carbon credit projects have been captured and summarized here. Furthermore, time and funding constraints limited the comprehensiveness of this table. Nonetheless, this table provides valuable insight into the methodologies currently used by entities in the region.

**Table 5: Summary of GHG accounting Protocols, Methodologies and Tools used by entities in the NCRP region, focused mainly on local government entities.**

Region of Organization	Name of Organization	Focus Entity or Action	Description	GHG Protocol, Methodology, and/or Tool
CA State	CARB	Statewide Community Emissions	Community emissions across primary economic sectors	IPCC 2006 Guidelines for National Greenhouse Gas Inventories + various state-specific tools
	Numerous State Departments: CalEPA, CPUC, DWR, etc.	Organization	Agency Operations	TCR — General Reporting Protocol
Entity or Region within NCRP territory	Northern California Power Agency	Organization	Company Operations	TCR — General Reporting Protocol
	PG&E	Organization	Company Operations	TCR — General Reporting Protocol
	All industrial facilities, fuel suppliers, and electricity importers that emit more than 25,000 MT CO <sub>2</sub> E annually	Organization	Company operations and imported electricity	CARB Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR)
Del Norte	Other Public and Private	Projects	Voluntary forest projects registered to ACR	CARB: U.S. Forest Projects Protocol
	County			Confirmed None
	NCUAQMD			Recommend CalEEMod tool, and CAPCOA guidance
	Del Norte Local Transportation Commission	Policy	2011 RTP EIR	None stated — speculative

Region of Organization	Name of Organization	Focus Entity or Action	Description	GHG Protocol, Methodology, and/or Tool	
Humboldt	Other Public and Private	Projects	Voluntary forest projects registered to ACR	CARB: U.S. Forest Projects Protocol	
	County	Organization	LG Operations - 2005 GHG Inventory	LGO Protocol	
		Community	Draft Climate Action Plan: 2012	Custom - ICLEI CACP	
		Community	2005/2010 GHG Inventories	ICLEI U.S. Community Protocol	
	NCUAQMD			Recommend CalEEMod tool, and CAPCOA guidance	
	HCAOG	Policy	13/14 RTP Update EIR	Custom - HumCo Regional Transportation Model + EMFAC	
	Arcata	Community	2001 GHG Inventory	Cities for Climate Protection (ICLEI)	
		Community	2006 GHG Inventory	Custom - Method specific to GHG Reduction Plan, with influence from LGO Protocol	
		Community	2005/2010 GHG Inventories	ICLEI U.S. Community Protocol, and the HCGHGEI Tool	
		Organization	LG Operations - 2005/2006/2010 GHG Inventories	LGO Protocol	
		Project	Multiple forest offset projects	Climate Action Reserve Forest Project Protocol	
	Blue Lake	Community	2005/2010 GHG Inventories	ICLEI U.S. Community Protocol, and the HCGHGEI Tool	
		Organization	LG Operations - 2005 GHG Inventory	LGO Protocol	
	Eureka	Community	2005 GHG Inventory	Custom + CACP Tool	
		Organization	2005 LG Operations Inventory	LGO Protocol	
		Community	2010 GHG Inventory	ICLEI U.S. Community Protocol, and the HCGHGEI Tool	
		Community	2010 GHG Inventory for CAP	Modification of above 2010 GHG Inventory by ICF International, the consultant that developed the CAP.	
	Ferndale	Community	2005/2010 GHG Inventories	ICLEI U.S. Community Protocol, and the HCGHGEI Tool	
		Organization	LG Operations - 2005 GHG Inventory	LGO Protocol	
	Fortuna	Community	2005/2010 GHG Inventories	ICLEI U.S. Community Protocol, and the HCGHGEI Tool	
		Organization	LG Operations - 2005 GHG Inventory	LGO Protocol	
	Rio Dell	Community	2005/2010 GHG Inventories	ICLEI U.S. Community Protocol, and the HCGHGEI Tool	
		Organization	LG Operations - 2005 GHG Inventory	LGO Protocol	
	Trinidad	Community	2005/2010 GHG Inventories	ICLEI U.S. Community Protocol, and the HCGHGEI Tool	
		Organization	LG Operations - 2005 GHG Inventory	LGO Protocol	
	Lake	Lake County City Area Planning Council	Policy	2010 Regional Transportation Plan CEQA NegDec	None stated - speculative



Region of Organization	Name of Organization	Focus Entity or Action	Description	GHG Protocol, Methodology, and/or Tool
<b>Mendocino</b>	Public and Private	Project	Voluntary forest projects registered to ACR	Climate Action Registry Forest Project Protocol CARB: U.S. Forest Projects Protocol
	County	Policy	2009 General Plan EIR	Custom - EPA Carbon Calculator for residences, EPA power profiler for commercial, URBEMIS for transportation
		Community	Climate Action Plan	ICLEI U.S. Community Protocol and LGO Protocol
	Mendocino AQMD			Recommends the use of BAAQMD GHG significance thresholds
	Fort Bragg	Community	Climate Action Plan	Cities for Climate Protection (ICLEI) protocol, but the website for this project lists the Local Government Protocol only. The methodology section ignores a significant number of sources which are included in the ICLEI Community Protocol
	Ukiah	Policy	Ukiah Valley Area Plan 2009 GHG Inventory	Custom methodology and data sources
<b>Modoc</b>	County			Confirmed None
<b>Siskiyou</b>	Public and Private	Project	Voluntary forest projects registered to ACR	1 Forest Carbon Projects registered to ACR - CARB: U.S. Forest Projects Protocol
	County			Confirmed None
<b>Sonoma</b>	County	Community	Center for Climate Protection (CCP) Inventories and Updates	Cities for Climate Protection (ICLEI)
		Community	GHG Inventory for 2008 Climate Action Plan	Custom Carbon Model tool developed by the Climate Protection Campaign
		Community	2010 GHG Inventory for Climate Action 2020 Plan	ICLEI U.S. Community Protocol + "alternative protocols were consulted including the Association of Environmental Professionals (AEP) white paper on baseline community inventories (Association of Environmental Professionals 2011) and Intergovernmental Panel on Climate Change (IPCC) (Intergovernmental Panel on Climate Change 2000) methodologies" (Climate Action 2020 Appendices)
		Community	2005 GHG Inventory	Custom + CACP Tool
	BAAQMD	Organization	Operations	The Climate Registry - General Reporting Protocol
	Sonoma County Water Agency	Organization	Operations	The Climate Registry - General Reporting Protocol
	Healdsburg	Community	CCP Inventories and Updates	Cities for Climate Protection (ICLEI)
	Rohnert Park	Community	CCP Inventories and Updates	Cities for Climate Protection (ICLEI)
	Santa Rosa	Community	CCP Inventories and Updates	Cities for Climate Protection (ICLEI)
	Sebastopol	Community	CCP Inventories and Updates	Cities for Climate Protection (ICLEI)
	Sonoma	Community	CCP Inventories and Updates	Cities for Climate Protection (ICLEI)
Windsor	Community	CCP Inventories and Updates	Cities for Climate Protection (ICLEI)	
<b>Trinity</b>	Public and Private	Project	Compliance listed in 3 CARB approved registries	Climate Action Registry - Forest Project Protocol
	County			Confirmed None
	NCUAQMD			Recommend CalEEMod tool, and CAPCOA guidance

## APPENDIX B: REVIEW OF ASSESSED PROTOCOLS AND METHODOLOGIES

The following table summarizes various greenhouse gas emissions inventory Methodologies and Protocols that have been developed by various organizations. This summary focuses on actively used and widely available inventories, and includes those used in the United States as well as in other countries around the world. The list is reflective of the current status as of June 2016. This list is extensive, but not comprehensive.

**Table 6: Summary table of identified emissions Methodologies and Protocols. Entries are grouped by Class, then by Focus Region.**

Author: Title	Features			Focus Entity or Action				
	Class <sup>4</sup>	Focus Region <sup>15</sup>	Recommended?	Community	Organization	Policy	Project	Product / Service
RCEA: Humboldt County Greenhouse Gas Emissions Inventory Tool: Based on ICLEI U.S. Community Protocol	A	L	Y	X				
California Air Resources Board: Low Carbon Fuel Standard	A	C						X
CalEPA: California Community-Wide Greenhouse Gas Baseline Inventory Protocol White Paper	A	C		X				
CARB: Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies (SCS) Pursuant to SB 375	A	C	Y	X				
ICLEI: US Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions	A	US	Y	X				
CARB, CCAR, ICLEI, TCR: Local Government Operations Protocol	A	US	Y		X			
ICLEI: Recycling and Composting Emissions Protocol	A	US	Y	X	X			
TCR: General Reporting Protocol	A	US			X			
TCR: Industry-specific protocols	A	US			X			X
USEPA-CL: Corporate Climate Leadership Guidance - Cross-Sector Guidance	A	US			X			
USEPA-CL: Corporate Climate Leadership Guidance - Sector-Specific Guidance	A	US			X			
U.S. Whitehouse: Federal GHG Accounting and Reporting Guidance	A	US			X			
US Federal Renewable Fuel Standard	A	US						X
US FHWA: Handbook for Estimating Transportation Greenhouse Gases for Integration into the Planning Process	A	US		X				
EPA: Life Cycle Assessment: Principles and Practice	A	US				X	X	X
UK Dept. of Transport: UK Renewable Transport Fuel Obligation Carbon and Sustainability Guidance	A	N				X		X
European Commission: Organization Environmental Footprint	A	N			X			
European Commission: Product Environmental Footprint	A	N						X
The Covenant of Mayors Initiative: Baseline Emissions Inventory/Monitoring Emissions Inventory Methodology	A	N		X				
WRI: Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard	A	G	Y		X			
WRI: Greenhouse Gas Protocol: Public Sector Protocol	A	G			X			
WRI / C40 / ICLEI: Greenhouse Gas Protocol: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories - An Accounting and Reporting Standard for Cities	A	G		X				
BSI: Specification for the assessment of greenhouse gas emissions of a city	A	G		X				
BSI: PAS 2050: Specification for the assessment of the life cycle greenhouse gas emissions of goods and services	A	G						X
BSI: PAS 2070: Specification for the assessment of greenhouse gas emissions of a city – Direct plus supply chain and consumption-based methodologies	A	G		X				
ISO: ISO/TC 207/SC 7 - Greenhouse gas management and related activities (Contains widely used ISO-14064 and ISO-14067)	A	G			X		X	X
ISO: ISO/TC 207/SC 5 - Life cycle assessment (Contains widely used ISO-14040 and ISO-14044)	A	G			X			X
IPCC: Guidelines for National Greenhouse Gas Inventories	A	G		X				

Author: Title	Features			Focus Entity or Action				
	Class <sup>14</sup>	Focus Region <sup>15</sup>	Recommended?	Community	Organization	Policy	Project	Product / Service
UNEP Life Cycle Initiative: Guidance on Organizational Life Cycle Assessment	A	G			X			
CARB: Method for estimating greenhouse gas emission reductions from compost from organic waste	C	C		X				
CARB: Method for estimating greenhouse gas emission reductions from recycling	C	C		X				
CAPCOA: Quantifying Greenhouse Gas Mitigation Measures	C	C	Y	X		X	X	
Various Authors: GHGRx approved protocols	C	C	Y		X		X	X
VCS: Verified Carbon Standard Methodologies	C	C	Y				X	
CAR: Climate Action Reserve Methodologies	C	C	Y				X	
ACR: American Carbon Registry Methodologies	C	C	Y				X	
TCR: General Verification Protocol	C	US					X	
CRS: Green-e Energy: National Standard for Certifying Renewable Energy Sources	C	US					X	X
WRI: Greenhouse Gas Protocol: Policy and Action Standard	C	G	Y			X		
WRI / WBCSD: Greenhouse Gas Protocol: Product Standard	A	G	Y					X
WRI / WBCSD: Greenhouse Gas Protocol: The GHG Protocol for Project Accounting	C	G					X	
UNFCCC: Clean Development Mechanism Methodologies	C	G		X		X	X	

## APPENDIX C: REVIEW OF ASSESSED TOOLS AND MODELS FOR ESTIMATING GREENHOUSE GAS EMISSIONS

The following table provides a partial list of an extensive array of available tools and models that can be used to estimate greenhouse gas (GHG) emissions. This list focuses only on tools and models that specifically output greenhouse gas emissions estimates. There are a large number of additional tools and models that can be used to obtain metrics that might be needed in order to use the models listed here. Also, tools that are specific to climate adaption topics are not included unless they allow the quantification of greenhouse gas emissions.

Tools and models are included if they are designed to be used in the state and/or in the NCRP region, or are specifically mentioned in the recommendations. While additional models and tools exist, they are not included if there is a model or tool that accomplishes the same task that is focused on the state or local region. For example, both the EPA and CARB maintain models for estimating mobile emissions sources. However, only those maintained by CARB are included as these are assumed to supersede the EPA models for application in the NCRP region.

**Table 7: Review of tools and models for estimating greenhouse gas emissions.**

Model or Tool	Author	Emissions Boundary	Focus Emissions Sector(s)	Protocol or Methodology Used
Humboldt County Greenhouse Gas Emissions Inventory Tool	RCEA	Inventory	Multiple	ICLEI U.S. Community Protocol
Category-specific off-road source models	CARB	Inventory	Transportation: Off-Road Mobile Sources	Model-specific
CoolCalifornia Carbon Calculator	CARB, Next10, RAEL	Footprint	Many	Model-specific
EMFAC	CARB	Inventory	Transportation: On-Road Mobile Sources	Model-specific
CT-EMFAC	CalTrans			
Waste Reduction Model (WARM and iWARM)	EPA	Inventory	Solid Waste	Model-specific
ecoSmart Landscapes	USFS, CalFire, EcoLayers	Inventory	Carbon Offset / Urban Forestry	Climate Action Reserve Urban Forest Project Protocol
USFS CarbonPlus Calculator	USFS	Inventory	Built Environment, Mobile and Off-road Equipment, Commercial Air Travel	Model-specific
I-PLACE <sup>3</sup> S		Inventory	Land Use, Transportation	Model-specific
CalEEMod	CARB	Inventory	Land Use, Transportation	Model-specific
SEEC ClearPath Tool	SEEC	Inventory	Many	ICLEI U.S. Community Protocol
Energy Star Portfolio Manager	EPA	Inventory	Built Environment, Solid Waste	N/A
WRI Guidance and Standards Tools	WRI and WBCSD	Either	Many	Associated Greenhouse Gas Protocol® Standard

**(Footnotes)**

1 A list of regulated large polluters that are required to annually report their GHG emissions to CARB can be found at [http://www.arb.ca.gov/ei/tools/ghg\\_visualization/](http://www.arb.ca.gov/ei/tools/ghg_visualization/). These entities must use the methodologies developed and provided by CARB.

2 See [1] for justification of why this class is not considered to apply to *this focus entity or action*. *This approach is taken in an attempt to simplify the decision matrix structure. However, the author acknowledges there are valid reasons to argue against this approach, and leaves discussion of these reasons to future work.*

3 See [1] and [16] for justification of why this class is not considered to apply to *this focus entity or action*. *This approach is taken in an attempt to simplify the decision matrix structure. However, the author acknowledges there are valid reasons to argue against this approach, and leaves discussion of these reasons to future work.*

4 See details regarding assessing energy conservation in CEQA Appendix F – II.H. However, note also that “life cycle emissions” are currently exempt from CEQA assessments [see [28] and [29]], which the author sees as potentially conflicting with CEQA Appendix F – II.H. Finally, to add additional confusion, CEQA distinguishes between direct and indirect emissions categories, and requires analysis of both. Ultimately the agency holding jurisdiction will dictate whether an emissions Footprint, as opposed to an Inventory, is needed for CEQA compliance.

5 For details on regulated entities refer to the California Code of Regulations, Title 17, §95811

6 For lists of entities that have completed compliance projects in the NCRP region visit the approved project registries listed by CARB at <http://www.arb.ca.gov/cc/capandtrade/offsets/registries/registries.htm> who maintain these lists.

7 Note that guidance for mandated GHG emissions assessments is only provided for projects regulated under CEQA as this regulation is extremely open-ended such that any Protocol or Methodology will meet requirements. All other focus entities or actions for which a mandatory GHG emissions assessment is being conducted should consult the mandating organization for guidance. This is indicated with the term (N)o (R)ecommendation (M)ade.

8 Note that there is debate regarding the class of the ISO 14040, 14044 and 14067 standards, to which the Greenhouse Gas Protocol® Product Standard is closely related. Identifying these standards as Attributional follows [1].

9 (A)griculture, (F)orestry, and (O)ther (L)and (U)se

10 Regarding what greenhouse gases to consider in an assessment. CEQA definition of GHGs is “includes but is not limited to: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.”

11 If the protocol being used by the practitioner does not specify a detailed equation or set of equations for calculating emissions associated with the potable water or wastewater Sectors, use the calculation guidance provided in the ICLEI U.S. Community Protocol

12 According to CalTrans the version of CT-EMFAC available as of the publication of this report is NOT to be used for CEQA conformity analysis. In other words, it should not be considered as a direct alternative to EMFAC. A future version, CT-EMFAC 5, is expected to be released soon and may be approved for conformity analysis pending review by CalEPA.

13 Every effort was made to only include very reputable sources of data. The rating of “Fair” does not refer to the reputability of these sources but on how appropriate or ideal they are. For example, many of these sources only contain national-level data, which is not as ideal for GHG assessments focused on a smaller scale, and should only be used if no other option is available to the practitioner. Note also that default data provided in a particular Protocol should in general be considered as a Fair source. Although a practitioner can be bound by the requirements of a particular Protocol or Methodology, every effort should be made to use data from those sources labeled Good or Best.

14 Class is either (A)tributional or (C)onsequential. Attributional emissions assessments look at the total emissions associated with a particular source or activity given a specified boundary. Consequential emissions

assessments look at the potential change in emissions associated with a particular activity, policy, or decision based on a defined baseline and boundary.

15 Focus region is the specific political geography that a methodology or protocol is defined for. For example, the EPA uses protocols developed by the World Resources Institute but modified the protocols specifically for use by the United States. Region is either (G)lobal, (N)ational, (U)nited (S)tates, (C)alifornia, or (L)ocal

