Report for ForestQuery into Global Deforestation, 1990 to 2016

ForestQuery is on a mission to combat deforestation around the world and to raise awareness about this topic and its impact on the environment. The data analysis team at ForestQuery has obtained data from the World Bank that includes forest area and total land area by country and year from 1990 to 2016, as well as a table of countries and the regions to which they belong.

The data analysis team has used SQL to bring these tables together and to query them in an effort to find areas of concern as well as areas that present an opportunity to learn from successes.

1. **GLOBAL SITUATION**

According to the World Bank, the total forest area of the world was 41282694.9 square kilometers in 1990. As of 2016, the most recent year for which data was available, that number had fallen to 39958245.9 square kilometers, a loss of 1324449 square kilometers, or 3.2%.

The forest area lost over this time period is slightly more than the entire land area of Peru listed for the year 2016 (which is 494208.49 square miles).

2. **REGIONAL OUTLOOK**

In 2016, the percent of the total land area of the world designated as forest was 31.38%. The region with the highest relative forestation was Latin America & Caribbean, with 46.16%, and the region with the lowest relative forestation was Middle East & North Africa, with 2.07% forestation.

In 1990, the percent of the total land area of the world designated as forest was 32.42%. The region with the highest relative forestation was Latin America & Caribbean, with 51.03%, and the region with the lowest relative forestation was Middle East & North Africa, with 1.78% forestation.

Table 2.1: Percent Forest Area by Region, 1990 & 2016:

Region	1990 Forest Percentage	2016 Forest Percentage
Latin America & Caribbean	51.03	46.16
Europe & Central Asia	37.28	38.04
North America	35.65	36.04
Sub-Saharan Africa	30.67	28.79
East Asia & Pacific	25.78	26.36
South Asia	16.51	17.51
Middle East & North Africa	1.78	2.07

The only regions of the world that decreased in percent forest area from 1990 to 2016 were Latin America & Caribbean (dropped from 51.03% to 46.16%) and Sub-Saharan Africa (30.67% to 28.79%). All other regions actually increased in forest area over this time period. However, the drop in forest area in the two aforementioned regions was so large, the percent forest area of the world decreased over this time period from 32.42% to 31.38%.

3. **COUNTRY-LEVEL DETAIL**

A. SUCCESS STORIES

There is one particularly bright spot in the data at the country level, China. This country actually increased in forest area from 1990 to 2016 by 527229 square kilometers. It would be interesting to study what has changed in this country over this time to drive this figure in the data higher. The country with the next largest increase in forest area from 1990 to 2016 was the United States, but it only saw an increase of 79200 square kilometers, much lower than the figure for China.

China and the United States are of course very large countries in total land area, so when we look at the largest *percent* change in forest area from 1990 to 2016, we aren't surprised to find a much smaller country listed at the top. Iceland increased in forest area by 213.66 % from 1990 to 2016.

B. LARGEST CONCERNS

Which countries are seeing deforestation to the largest degree? We can answer this question in two ways. First, we can look at the absolute square kilometer decrease in forest area from 1990 to 2016. The following 5 countries had the largest decrease in forest area over the time period under consideration:

Table 3.1: Top 5 Amount Decrease in Forest Area by Country, 1990 & 2016:

Country	Region	Absolute Forest Area Change
Brazil	Latin America & Caribbean	541510
Indonesia	East Asia & Pacific	282194
Myanmar	East Asia & Pacific	107234
Nigeria	Sub-Saharan Africa	106506
Tanzania	Sub-Saharan Africa	102320

The second way to consider which countries are of concern is to analyze the data by percent decrease.

Table 3.2: Top 5 Percent Decrease in Forest Area by Country, 1990 & 2016:

Country	Region	Pct Forest Area Change
Togo	Sub-Saharan Africa	75.45
Nigeria	Sub-Saharan Africa	61.80
Uganda	Sub-Saharan Africa	59.13
Mauritania	Sub-Saharan Africa	46.75
Honduras	Latin America & Caribbean	45.03

When we consider countries that decreased in forest area percentage the most between 1990 and 2016, we find that four of the top 5 countries on the list are in the region of Sub-Saharan Africa. The countries are Togo, Nigeria, Uganda, and Mauritania. The 5th country on the list is Honduras, which is in the Latin America & Caribbean region.

From the above analysis, we see that Nigeria is the only country that ranks in the top 5 both in terms of absolute square kilometer decrease in forest as well as percent decrease in forest area from 1990 to 2016. Therefore, this country has a significant opportunity ahead to stop the decline and hopefully spearhead remedial efforts.

C. QUARTILES

Table 3.3: Count of Countries Grouped by Forestation Percent Quartiles, 2016:

Quartile	Number of Countries
1	85
2	73
3	38
4	9

The largest number of countries in 2016 were found in the first quartile.

There were 9 countries in the top quartile in 2016. These are countries with a very high percentage of their land area designated as forest. The following is a list of countries and their respective forest land, denoted as a percentage.

Table 3.4: Top Quartile Countries, 2016:

Country	Region	Pct Designated as Forest
Suriname	Latin America & Caribbean	98.26
Micronesia, Fed. Sts.	East Asia & Pacific	91.86
Gabon	Sub-Saharan Africa	90.04
Seychelles	Sub-Saharan Africa	88.41
Palau	East Asia & Pacific	87.61
American Samoa	East Asia & Pacific	87.50
Guyana	Latin America & Caribbean	83.90
Lao PDR	East Asia & Pacific	82.11
Solomon Islands	East Asia & Pacific	77.86

5. RECOMMENDATIONS

The World Bank data show an overall decrease of forest land on earth by 3.2%. This worldwide decrease in forest land was primarily driven by countries of two regions: the Latin American & Caribbean region as well as the Sub-Saharan African region. In contrast to these two regions, all of the remaining regions showed an increase in forest land from the year of 1990 to 2016. Analyzing the specific contribution of individual countries revealed that particularly four countries in the Sub-Saharan African region showed the most pronounced percentage decrease of forest land from 1990 to 2016. These include the countries of Togo, Nigeria, Uganda and Mauritania. Notably, Nigeria revealed the second largest amount of percentage decrease in forest land with a decrease of 61.8% and was also present in the top five countries with the largest amount of decrease of forest land in square kilometers. Nigeria is therefore a country that should be of particular focus for future initiatives trying to reforest land and stop further deforestation.
Besides these African regions, future initiatives should also focus on countries that showed a particularly large decrease in overall forest area from 1990 to 2016 such as Brazil. This country showed the largest drop of total forest land from 1990 to 2016 revealing a decrease of 541510 square kilometers. Protecting the rainforest of Brazil in future initiatives to prevent a further increase in deforestation appears therefore essential.
Besides these countries of concern, the World Bank data also shed light on countries that increased their amount of forest land from 1990 to 2016. In terms of total increase of forest land, highlights are China and the United States. Taking the overall land area of the country into consideration by computing the percentage of forest land increase, Iceland ranked first in terms

of percentage increase of forest land. Despite the fact that the majority of countries showed increases in forest land over the investigated time period, which gives rise to optimism, more than two thirds of the countries reveal a forestation that comprises less than 50% of the land area. Moreover, the data do not show how healthy the forest is in the year 2016 in relation to 1990. Consequently, there remains a lot of work for future initiatives that target to increase this world's forestation.

6. APPENDIX: SQL queries used

```sql
/* Building a View */

CREATE VIEW forestation
AS
SELECT f.*,
      l.total_area_sq_mi,
      r.region,
      r.income_group,
      (f.forest_area_sqkm / (l.total_area_sq_mi * 2.59) * 100) AS
      forest_area_pct
FROM forest_area f
INNER JOIN land_area l
ON f.country_code = l.country_code AND f.year = l.year
INNER JOIN regions r
ON l.country_code = r.country_code;


/* Part 1 - Global Situation */
/* Question a. What was the total forest area (in sq km) of the world in
1990? */

SELECT country_code, country_name, year, forest_area_sqkm
FROM forestation
WHERE year = 1990 AND country_name = 'World'



/* Question b. What was the total forest area (in sq km) of the world in
2016?  */

SELECT country_code, country_name, year, forest_area_sqkm
FROM forestation
WHERE year = 2016 AND country_name = 'World'
```

```sql
/* Question c. What was the change (in sq km) in the forest area of the
world from 1990 to 2016?   */

WITH t1 AS (
             SELECT country_code, country_name, year, forest_area_sqkm
             FROM forestation
             WHERE year = 1990 AND country_name = 'World'),

     t2 AS (
             SELECT country_code, country_name, year, forest_area_sqkm
             FROM forestation
             WHERE year = 2016 AND country_name = 'World')

SELECT t1.forest_area_sqkm - t2.forest_area_sqkm AS change_in_forest_area
FROM t1
INNER JOIN t2
ON t1.country_code = t2.country_code



/* Question d. What was the percent change in forest area of the world
between 1990 and 2016? */

WITH t1 AS (
             SELECT country_code, country_name, year, forest_area_sqkm
             FROM forestation
             WHERE year = 1990 AND country_name = 'World'),

     t2 AS (
             SELECT country_code, country_name, year, forest_area_sqkm
             FROM forestation
             WHERE year = 2016 AND country_name = 'World')

SELECT ((t1.forest_area_sqkm - t2.forest_area_sqkm) / t1.forest_area_sqkm)
* 100 AS pct_change_in_forest_area
FROM t1
INNER JOIN t2
ON t1.country_code = t2.country_code
```

```sql
/* Question e. If you compare the amount of forest area lost between 1990
and 2016, to which country's total area in 2016 is it closest to? */

SELECT country_code, country_name, year, total_area_sq_mi
FROM forestation
WHERE (total_area_sq_mi * 2.59) <
            (WITH t1 AS (
                        SELECT country_code, country_name, year,
                               forest_area_sqkm
                        FROM forestation
                        WHERE year = 1990 AND country_name = 'World'
                        LIMIT 1),

                  t2 AS (
                        SELECT country_code, country_name, year,
                               forest_area_sqkm
                        FROM forestation
                        WHERE year = 2016 AND country_name = 'World'
                        LIMIT 1)

                  SELECT t1.forest_area_sqkm - t2.forest_area_sqkm AS
                         change_in_forest_area
            FROM t1
            INNER JOIN t2
            ON t1.country_code = t2.country_code)
            AND year = 2016
ORDER BY total_area_sq_mi DESC
LIMIT 1
```

```sql
/* PART 2 - REGIONAL OUTLOOK */

/* Question a. What was the percent forest of the entire world in 2016?
Which region had the HIGHEST percent forest in 2016, and which had the
LOWEST, to 2 decimal places? */

WITH t1 AS (
       SELECT region,
          year,
          SUM(forest_area_sqkm) / SUM(total_area_sq_mi * 2.59) *100 AS
              pct_forest_area
       FROM forestation
       WHERE year = 1990 OR year = 2016
       GROUP BY 2,1
       ORDER BY 2,1)
SELECT region, year, ROUND(CAST(pct_forest_area AS numeric),2) AS
pct_forest
FROM t1
WHERE year = 2016
ORDER BY pct_forest_area DESC


/* Question b. What was the percent forest of the entire world in 1990?
Which region had the HIGHEST percent forest in 1990, and which had the
LOWEST, to 2 decimal places? */

WITH t1 AS (
       SELECT region,
          year,
          SUM(forest_area_sqkm) / SUM(total_area_sq_mi * 2.59) *100 AS
             pct_forest_area
        FROM forestation
        WHERE year = 1990 OR year = 2016
        GROUP BY 2,1
        ORDER BY 2,1)
SELECT region, year, ROUND(CAST(pct_forest_area AS numeric),2) AS
pct_forest
FROM t1
WHERE year = 1990
ORDER BY pct_forest_area DESC
```

```sql
/* Question c. Based on the table you created, which regions of the world
DECREASED in forest area from 1990 to 2016? */

WITH t1 AS (
      SELECT region,
             year,
             SUM(forest_area_sqkm) / SUM(total_area_sq_mi * 2.59) *100 AS
                 pct_forest_area
             FROM forestation
             WHERE year = 1990 OR year = 2016
             GROUP BY 2,1
             ORDER BY 2,1)
SELECT region,
       year,
       pct_forest_area,
       LAG(pct_forest_area) OVER (PARTITION BY region ORDER BY year) AS
       lag_forest_1990,
       LAG(pct_forest_area) OVER (PARTITION BY region ORDER BY year) -
       pct_forest_area AS diff,
       CASE WHEN (LAG(pct_forest_area) OVER (PARTITION BY region ORDER BY
       year) - pct_forest_area) > 0 THEN 1 ELSE 0 END AS
       decreased_forest_area
FROM t1
```

```sql
/* PART 3 - COUNTRY-LEVEL DETAIL */

/* Question a. Which 5 countries saw the largest amount decrease in forest
area from 1990 to 2016? What was the difference in forest area for each? */

/* For part 3.A SUCCESS STORIES inverse the ordering by using: ORDER BY
diff */

WITH t1 AS (
           SELECT country_name,
                region,
                year,
                forest_area_sqkm,
                LAG(forest_area_sqkm) OVER (PARTITION BY country_name ORDER
                BY year) AS lag_forest_1990,
                LAG(forest_area_sqkm) OVER (PARTITION BY country_name ORDER
                BY year) - forest_area_sqkm AS diff
           FROM forestation
           WHERE year = 1990 OR year = 2016
           GROUP BY 1,2,3,4)

SELECT country_name, region, year, forest_area_sqkm, lag_forest_1990, diff
FROM t1
WHERE NOT diff IS NULL AND country_name != 'World'
ORDER BY diff DESC
LIMIT 5
```

```sql
/* Question b. Which 5 countries saw the largest percent decrease in forest
area from 1990 to 2016? What was the percent change to 2 decimal places for
each? */

/* For part 3.A SUCCESS STORIES inverse the ordering by using: ORDER BY
pct_diff */

WITH t1 AS (
     SELECT country_name,
            region,
            year,
            forest_area_sqkm,
            LAG(forest_area_sqkm) OVER (PARTITION BY country_name ORDER BY
            year) AS lag_forest_1990,
            LAG(forest_area_sqkm) OVER (PARTITION BY country_name ORDER BY
            year) - forest_area_sqkm AS diff
     FROM forestation
     WHERE year = 1990 OR year = 2016
     GROUP BY 1,2,3,4)

SELECT country_name, region, year, forest_area_sqkm, lag_forest_1990, diff,
       ROUND(CAST((diff/lag_forest_1990 *100) AS numeric), 2) AS pct_diff
FROM t1
WHERE NOT diff IS NULL AND country_name != 'World'
ORDER BY pct_diff DESC
LIMIT 5
```

```sql
/* Question c. If countries were grouped by percent forestation in
quartiles, which group had the most countries in it in 2016? */

WITH t1 AS (
  SELECT country_name,
         year,
         SUM(forest_area_sqkm) / SUM(total_area_sq_mi * 2.59) *100 AS
         pct_forest
  FROM forestation
  WHERE year = 2016 AND
                NOT total_area_sq_mi IS NULL AND
                NOT forest_area_sqkm IS NULL
  GROUP BY 1,2)

SELECT
       CASE WHEN pct_forest <= 25.00 THEN 1
       WHEN pct_forest > 25.0 AND  pct_forest <= 50.00 THEN 2
       WHEN pct_forest > 50.00 AND pct_forest <= 75.00 THEN 3
       ELSE 4 END AS quartile_split,
       COUNT(*)
FROM t1
GROUP BY 1
ORDER BY 1
```

```sql
/* Question d. List all of the countries that were in the 4th quartile
(percent forest > 75%) in 2016. */

WITH t1 AS (
  SELECT country_name,
         region,
         year,
         SUM(forest_area_sqkm) / SUM(total_area_sq_mi * 2.59) *100 AS
         pct_forest
  FROM forestation
  WHERE year = 2016 AND
                NOT total_area_sq_mi IS NULL AND
                NOT forest_area_sqkm IS NULL
  GROUP BY 1,2,3)

SELECT country_name, region, pct_forest
FROM t1
WHERE pct_forest > 75.00
ORDER BY 3 DESC
```

```sql
/* Question e. How many countries had a percent forestation higher than the
United States in 2016? */

WITH t1 AS (
  SELECT country_name,
         region,
         year,
         SUM(forest_area_sqkm) / SUM(total_area_sq_mi * 2.59) *100 AS
         pct_forest
  FROM forestation
  WHERE year = 2016 AND
               NOT total_area_sq_mi IS NULL AND
               NOT forest_area_sqkm IS NULL
  GROUP BY 1,2,3),

  t2 AS (SELECT forest_area_pct
         FROM forestation
         WHERE year = 2016 AND country_code = 'USA')

SELECT COUNT(*)
FROM t1
WHERE pct_forest >
                   (SELECT forest_area_pct
                    FROM t2)


/* 94 countries had a percent forestation higher than the United States in
2016 */
```