In [1]:
```
from torchvision import transforms, datasets
from torch.utils.data import DataLoader
import torch

train_transform = transforms.Compose([
    transforms.Resize((224, 224)),
    transforms.ToTensor()
])

valid_test_transform = transforms.Compose([
    transforms.Resize((224, 224)),
    transforms.ToTensor()
])

train_dataset = datasets.ImageFolder('.././wildfire-dataset/train', transform=train_t
valid_dataset = datasets.ImageFolder('.././wildfire-dataset/valid', transform=valid_t
test_dataset = datasets.ImageFolder('.././wildfire-dataset/test', transform=valid_tes

train_loader = DataLoader(train_dataset, batch_size=32, shuffle=True)
valid_loader = DataLoader(valid_dataset, batch_size=32, shuffle=False)
test_loader = DataLoader(test_dataset, batch_size=32, shuffle=False)
```

In [2]:
```
from PIL import ImageFile
ImageFile.LOAD_TRUNCATED_IMAGES = True
```

In [3]:

```python
from transformers import ViTModel
from torch import nn
import torch.optim as optim

class CustomViTForBinaryClassification(nn.Module):
    def __init__(self, model_name, num_labels=1, dropout_rate=0.1):
        super(CustomViTForBinaryClassification, self).__init__()
        self.vit = ViTModel.from_pretrained(model_name)
        self.dropout = nn.Dropout(dropout_rate)
        self.classifier = nn.Linear(self.vit.config.hidden_size, num_labels)

    def forward(self, pixel_values):
        outputs = self.vit(pixel_values=pixel_values)
        output = self.dropout(outputs.last_hidden_state[:, 0, :])
        return self.classifier(output)

model_name = 'google/vit-base-patch16-224-in21k'
model = CustomViTForBinaryClassification(model_name)

for param in model.parameters():
    param.requires_grad = False

unfreeze_layers = ['layer.9.', 'layer.10.', 'layer.11.', 'vit.layernorm.', 'classifie

for name, param in model.named_parameters():
    if any(layer in name for layer in unfreeze_layers):
        print(f"Unfreezing layer: {name}")
        param.requires_grad = True
```

```
Unfreezing layer: vit.encoder.layer.9.attention.attention.query.weight
Unfreezing layer: vit.encoder.layer.9.attention.attention.query.bias
Unfreezing layer: vit.encoder.layer.9.attention.attention.key.weight
Unfreezing layer: vit.encoder.layer.9.attention.attention.key.bias
Unfreezing layer: vit.encoder.layer.9.attention.attention.value.weight
Unfreezing layer: vit.encoder.layer.9.attention.attention.value.bias
Unfreezing layer: vit.encoder.layer.9.attention.output.dense.weight
Unfreezing layer: vit.encoder.layer.9.attention.output.dense.bias
Unfreezing layer: vit.encoder.layer.9.intermediate.dense.weight
Unfreezing layer: vit.encoder.layer.9.intermediate.dense.bias
Unfreezing layer: vit.encoder.layer.9.output.dense.weight
Unfreezing layer: vit.encoder.layer.9.output.dense.bias
Unfreezing layer: vit.encoder.layer.9.layernorm_before.weight
Unfreezing layer: vit.encoder.layer.9.layernorm_before.bias
Unfreezing layer: vit.encoder.layer.9.layernorm_after.weight
Unfreezing layer: vit.encoder.layer.9.layernorm_after.bias
Unfreezing layer: vit.encoder.layer.10.attention.attention.query.weight
Unfreezing layer: vit.encoder.layer.10.attention.attention.query.bias
Unfreezing layer: vit.encoder.layer.10.attention.attention.key.weight
Unfreezing layer: vit.encoder.layer.10.attention.attention.key.bias
Unfreezing layer: vit.encoder.layer.10.attention.attention.value.weight
Unfreezing layer: vit.encoder.layer.10.attention.attention.value.bias
Unfreezing layer: vit.encoder.layer.10.attention.output.dense.weight
Unfreezing layer: vit.encoder.layer.10.attention.output.dense.bias
Unfreezing layer: vit.encoder.layer.10.intermediate.dense.weight
Unfreezing layer: vit.encoder.layer.10.intermediate.dense.bias
Unfreezing layer: vit.encoder.layer.10.output.dense.weight
Unfreezing layer: vit.encoder.layer.10.output.dense.bias
Unfreezing layer: vit.encoder.layer.10.layernorm_before.weight
Unfreezing layer: vit.encoder.layer.10.layernorm_before.bias
Unfreezing layer: vit.encoder.layer.10.layernorm_after.weight
Unfreezing layer: vit.encoder.layer.10.layernorm_after.bias
Unfreezing layer: vit.encoder.layer.11.attention.attention.query.weight
Unfreezing layer: vit.encoder.layer.11.attention.attention.query.bias
Unfreezing layer: vit.encoder.layer.11.attention.attention.key.weight
Unfreezing layer: vit.encoder.layer.11.attention.attention.key.bias
Unfreezing layer: vit.encoder.layer.11.attention.attention.value.weight
Unfreezing layer: vit.encoder.layer.11.attention.attention.value.bias
Unfreezing layer: vit.encoder.layer.11.attention.output.dense.weight
Unfreezing layer: vit.encoder.layer.11.attention.output.dense.bias
Unfreezing layer: vit.encoder.layer.11.intermediate.dense.weight
Unfreezing layer: vit.encoder.layer.11.intermediate.dense.bias
Unfreezing layer: vit.encoder.layer.11.output.dense.weight
Unfreezing layer: vit.encoder.layer.11.output.dense.bias
Unfreezing layer: vit.encoder.layer.11.layernorm_before.weight
Unfreezing layer: vit.encoder.layer.11.layernorm_before.bias
Unfreezing layer: vit.encoder.layer.11.layernorm_after.weight
Unfreezing layer: vit.encoder.layer.11.layernorm_after.bias
Unfreezing layer: vit.layernorm.weight
Unfreezing layer: vit.layernorm.bias
Unfreezing layer: classifier.weight
Unfreezing layer: classifier.bias
```

In [4]:

```python
import torch.optim as optim
from torch.optim.lr_scheduler import ReduceLROnPlateau

optimizer = optim.Adam(filter(lambda p: p.requires_grad, model.parameters()), lr=5e-5

criterion = nn.BCEWithLogitsLoss()

scheduler = ReduceLROnPlateau(optimizer, mode='min', factor=0.1, patience=2)
```

In [5]:
```python
# Optional: Print unfrozen layers to verify
for name, param in model.named_parameters():
    if param.requires_grad:
        print(name)
```

```
vit.encoder.layer.9.attention.attention.query.weight
vit.encoder.layer.9.attention.attention.query.bias
vit.encoder.layer.9.attention.attention.key.weight
vit.encoder.layer.9.attention.attention.key.bias
vit.encoder.layer.9.attention.attention.value.weight
vit.encoder.layer.9.attention.attention.value.bias
vit.encoder.layer.9.attention.output.dense.weight
vit.encoder.layer.9.attention.output.dense.bias
vit.encoder.layer.9.intermediate.dense.weight
vit.encoder.layer.9.intermediate.dense.bias
vit.encoder.layer.9.output.dense.weight
vit.encoder.layer.9.output.dense.bias
vit.encoder.layer.9.layernorm_before.weight
vit.encoder.layer.9.layernorm_before.bias
vit.encoder.layer.9.layernorm_after.weight
vit.encoder.layer.9.layernorm_after.bias
vit.encoder.layer.10.attention.attention.query.weight
vit.encoder.layer.10.attention.attention.query.bias
vit.encoder.layer.10.attention.attention.key.weight
vit.encoder.layer.10.attention.attention.key.bias
vit.encoder.layer.10.attention.attention.value.weight
vit.encoder.layer.10.attention.attention.value.bias
vit.encoder.layer.10.attention.output.dense.weight
vit.encoder.layer.10.attention.output.dense.bias
vit.encoder.layer.10.intermediate.dense.weight
vit.encoder.layer.10.intermediate.dense.bias
vit.encoder.layer.10.output.dense.weight
vit.encoder.layer.10.output.dense.bias
vit.encoder.layer.10.layernorm_before.weight
vit.encoder.layer.10.layernorm_before.bias
vit.encoder.layer.10.layernorm_after.weight
vit.encoder.layer.10.layernorm_after.bias
vit.encoder.layer.11.attention.attention.query.weight
vit.encoder.layer.11.attention.attention.query.bias
vit.encoder.layer.11.attention.attention.key.weight
vit.encoder.layer.11.attention.attention.key.bias
vit.encoder.layer.11.attention.attention.value.weight
vit.encoder.layer.11.attention.attention.value.bias
vit.encoder.layer.11.attention.output.dense.weight
vit.encoder.layer.11.attention.output.dense.bias
vit.encoder.layer.11.intermediate.dense.weight
vit.encoder.layer.11.intermediate.dense.bias
vit.encoder.layer.11.output.dense.weight
vit.encoder.layer.11.output.dense.bias
vit.encoder.layer.11.layernorm_before.weight
vit.encoder.layer.11.layernorm_before.bias
vit.encoder.layer.11.layernorm_after.weight
vit.encoder.layer.11.layernorm_after.bias
vit.layernorm.weight
vit.layernorm.bias
classifier.weight
classifier.bias
```

In [6]:

```python
print(model)

for name, module in model.named_modules():
    print(name, module)

total_params = sum(p.numel() for p in model.parameters() if p.requires_grad)
print(f"Total trainable parameters: {total_params}")
```

```
CustomViTForBinaryClassification(
  (vit): ViTModel(
    (embeddings): ViTEmbeddings(
      (patch_embeddings): ViTPatchEmbeddings(
        (projection): Conv2d(3, 768, kernel_size=(16, 16), stride=(16, 16))
      )
      (dropout): Dropout(p=0.0, inplace=False)
    )
    (encoder): ViTEncoder(
      (layer): ModuleList(
        (0-11): 12 x ViTLayer(
          (attention): ViTAttention(
            (attention): ViTSelfAttention(
              (query): Linear(in_features=768, out_features=768, bias=True)
              (key): Linear(in_features=768, out_features=768, bias=True)
              (value): Linear(in_features=768, out_features=768, bias=True)
              (dropout): Dropout(p=0.0, inplace=False)
            )
            (output): ViTSelfOutput(
```

In [7]:
```python
import numpy as np
import os
import time

# Checkpoint Saving
def save_checkpoint(state, filename="model_checkpoint.pth.tar"):
    torch.save(state, filename)

# Early Stopping
class EarlyStopping:
    """Stops training when validation loss doesn't improve after a given patience."""
    def __init__(self, patience=7, verbose=False, delta=0, model_name='model'):
        self.patience = patience
        self.verbose = verbose
        self.counter = 0
        self.best_score = None
        self.early_stop = False
        self.val_loss_min = np.Inf
        self.delta = delta
        self.model_name = model_name  # Add a model_name attribute

    def __call__(self, val_loss, model):
        score = -val_loss

        if self.best_score is None:
            self.best_score = score
            self.save_checkpoint(val_loss, model)
        elif score < self.best_score + self.delta:
            self.counter += 1
            if self.verbose:
                print(f'EarlyStopping counter: {self.counter} out of {self.patience}'
            if self.counter >= self.patience:
                self.early_stop = True
        else:
            self.best_score = score
            self.save_checkpoint(val_loss, model)
            self.counter = 0

    def save_checkpoint(self, val_loss, model):
        '''Saves model when validation loss decreases.'''
        if self.verbose:
            print(f'Validation loss decreased ({self.val_loss_min:.6f} --> {val_loss:
        # Use self.model_name to create the filename
        save_checkpoint(model.state_dict(), filename=f'{self.model_name}.weights.pth.
        self.val_loss_min = val_loss
```

In [8]:
```python
# Set the device to MPS if available, otherwise fall back to CPU
device = torch.device("mps" if torch.backends.mps.is_available() else "cpu")
print(f"Using device: {device}")
model = model.to(device)
```

```
Using device: mps
```

In [9]:

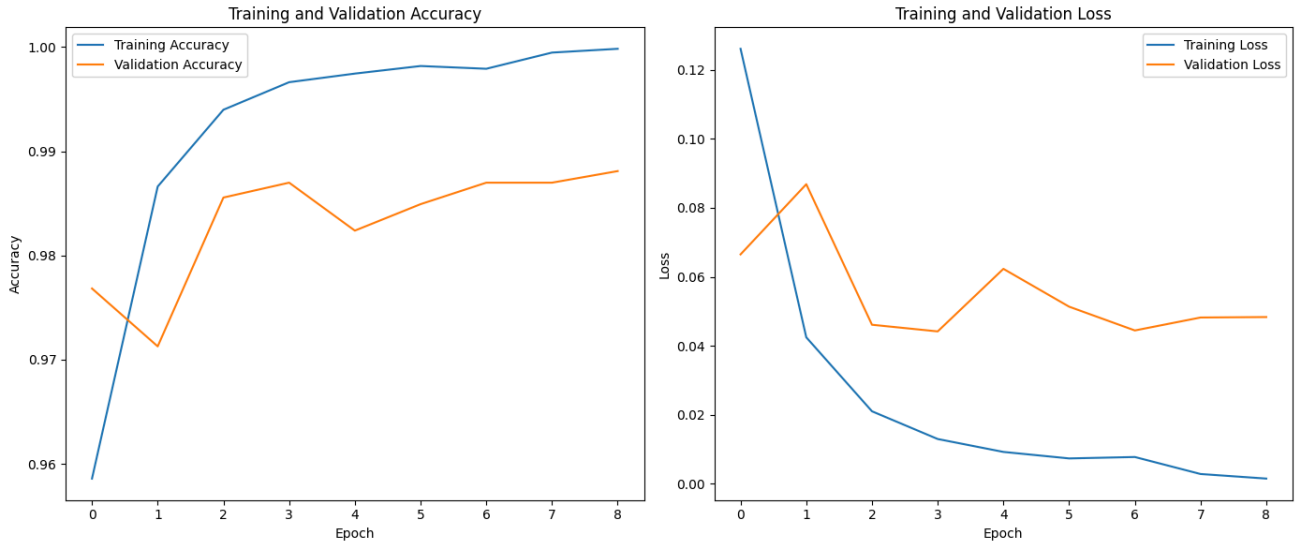
```
%%time
import copy
import time
import numpy as np

model_name = "ViTForImageClassification"
early_stopper = EarlyStopping(patience=5, verbose=True, model_name=model_name)
val_loss_history = []
loss_history = []
acc_history = []
val_acc_history = []
best_model_wts = copy.deepcopy(model.state_dict())
best_loss = np.inf

# Initialize lists for collecting predictions and actual labels during validation
all_preds = []
all_labels = []

start_time = time.time()

for epoch in range(10):
    print(f'Epoch {epoch+1}/{10}')
    print('-' * 10)

    model.train()
    total_train_loss = 0
    total_train_correct = 0

    for i, (inputs, labels) in enumerate(train_loader):
        inputs, labels = inputs.to(device), labels.to(device)

        optimizer.zero_grad()

        with torch.set_grad_enabled(True):
            outputs = model(inputs)  # These are logits
            loss = criterion(outputs, labels.unsqueeze(1).float())
            preds = torch.sigmoid(outputs) > 0.5  # Convert logits to probabilities a
            loss.backward()
            optimizer.step()

        total_train_loss += loss.item()
        total_train_correct += torch.sum(preds.squeeze().long() == labels.data)

        if (i + 1) % 100 == 0:  # Print every 100 batches
            print(f'Batch {i + 1}/{len(train_loader)}, Loss: {loss.item():.4f}')

    epoch_loss = total_train_loss / len(train_loader)
    epoch_acc = total_train_correct.float() / len(train_loader.dataset)

    loss_history.append(epoch_loss)
    acc_history.append(epoch_acc.item())

    print(f'Training Loss: {epoch_loss:.4f} Acc: {epoch_acc:.4f}')

    # Validation phase
    model.eval()
    total_val_loss = 0
    total_val_correct = 0

    for inputs, labels in valid_loader:
        inputs, labels = inputs.to(device), labels.to(device)

        with torch.no_grad():
            outputs = model(inputs)
            loss = criterion(outputs, labels.unsqueeze(1).float())
```

```
            preds = torch.sigmoid(outputs) > 0.5  # Again, convert logits to binary pr

            all_preds.extend(preds.cpu().numpy().squeeze())  # Adjust collection to m
            all_labels.extend(labels.cpu().numpy())

        total_val_loss += loss.item()
        total_val_correct += torch.sum(preds.squeeze().long() == labels.data)

    avg_val_loss = total_val_loss / len(valid_loader)
    val_loss_history.append(avg_val_loss)
    val_acc = total_val_correct.float() / len(valid_loader.dataset)
    val_acc_history.append(val_acc.item())

    print(f'Validation Loss: {avg_val_loss:.4f} Acc: {val_acc:.4f}')

    early_stopper(avg_val_loss, model)

    if avg_val_loss < best_loss:
        best_loss = avg_val_loss
        best_model_wts = copy.deepcopy(model.state_dict())

    if early_stopper.early_stop:
        print("Early stopping")
        break

    scheduler.step(avg_val_loss)

model.load_state_dict(best_model_wts)
time_elapsed = time.time() - start_time
print(f'Training complete in {time_elapsed // 60:.0f}m {time_elapsed % 60:.0f}s')
print(f'Best val Loss: {best_loss:.4f}')
```

```
Epoch 9/10
----------
Batch 100/946, Loss: 0.0004
Batch 200/946, Loss: 0.0003
Batch 300/946, Loss: 0.0006
Batch 400/946, Loss: 0.0006
Batch 500/946, Loss: 0.0004
Batch 600/946, Loss: 0.0005
Batch 700/946, Loss: 0.0005
Batch 800/946, Loss: 0.0006
Batch 900/946, Loss: 0.0003
Training Loss: 0.0015 Acc: 0.9998
Validation Loss: 0.0483 Acc: 0.9881
EarlyStopping counter: 5 out of 5
Early stopping
Training complete in 265m 36s
Best val Loss: 0.0442
CPU times: user 32min 18s, sys: 3h 15min 6s, total: 3h 47min 24s
Wall time: 4h 25min 36s
```

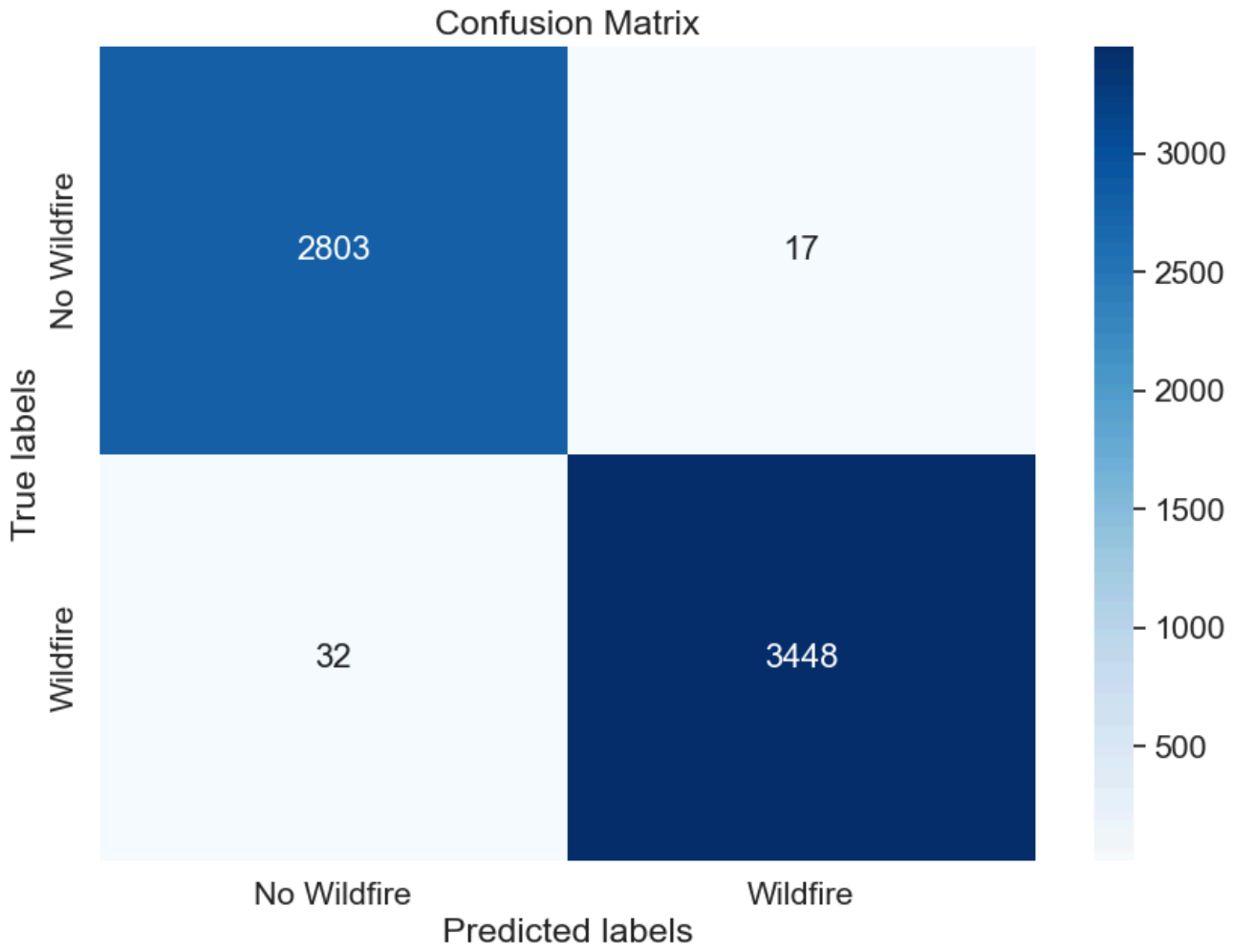
In [10]:

```
import matplotlib.pyplot as plt

# Plotting training and validation accuracy
plt.figure(figsize=(14, 6))
plt.subplot(1, 2, 1)
plt.plot(acc_history, label='Training Accuracy')
plt.plot(val_acc_history, label='Validation Accuracy')
plt.title('Training and Validation Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()

# Plotting training and validation loss
plt.subplot(1, 2, 2)
plt.plot(loss_history, label='Training Loss')
plt.plot(val_loss_history, label='Validation Loss')
plt.title('Training and Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()

plt.tight_layout()
plt.show()
```



In [11]:

```
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
from sklearn.metrics import confusion_matrix, accuracy_score, classification_report

model.eval()

test_preds = []
test_labels = []

with torch.no_grad():
    for inputs, labels in test_loader:
        inputs = inputs.to(device)
        outputs = model(inputs)

        preds = torch.sigmoid(outputs) > 0.5
        test_preds.extend(preds.squeeze().cpu().numpy())
        test_labels.extend(labels.cpu().numpy())

test_preds = np.array(test_preds)
test_labels = np.array(test_labels)

conf_matrix = confusion_matrix(test_labels, test_preds)

plt.figure(figsize=(10, 7))
sns.set(font_scale=1.4) # for label size
sns.heatmap(conf_matrix, annot=True, annot_kws={"size": 16}, fmt='g', cmap='Blues', x
plt.xlabel('Predicted labels')
plt.ylabel('True labels')
plt.title('Confusion Matrix')
plt.savefig('confusion_matrix.png')
plt.show()

accuracy = accuracy_score(test_labels, test_preds)
report = classification_report(test_labels, test_preds, target_names=['No Wildfire',

print(f"Accuracy: {accuracy * 100:.2f}%")
print("Classification Report:")
print(report)
```




```
Accuracy: 99.22%
Classification Report:
              precision    recall  f1-score   support

 No Wildfire       0.99      0.99      0.99      2820
    Wildfire       1.00      0.99      0.99      3480

    accuracy                           0.99      6300
   macro avg       0.99      0.99      0.99      6300
weighted avg       0.99      0.99      0.99      6300
```

In [ ]: